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UPPER PORTION UPPER MISSISSIPPI RIVER DRAIN-
AGE BASIN. A COOPERATIVE STATE-FEDERAL
REPORT ON WATER POLLUTION

Public Health Service
Chicago, Illinois

1953

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For Clean Water "One River, One Plan"

UPPER PORTION UPPER MISSISSIPPI RIVER DRAINAGE BASIN

A COOPERATIVE STATE FEDERAL REPORT ON WATER POLLUTION

1953



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Department of Health

**U. S. DEPARTMENT OF
HEALTH EDUCATION AND WELFARE**
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A REPORT ON WATER POLLUTION
IN THE
UPPER PORTION
UPPER MISSISSIPPI RIVER BASIN

Prepared by

MINNESOTA DEPARTMENT OF HEALTH
Division of Environmental Sanitation
Section of Water Pollution Control

PUBLIC HEALTH SERVICE
Division of Water Pollution Control
Upper Mississippi and Great Lakes Drainage Basins Office

DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
Public Health Service

1953

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INTRODUCTION

This report was produced cooperatively by the Minnesota Department of Health, Section of Water Pollution Control, and the Public Health Service, Division of Water Pollution Control, Upper Mississippi and Great Lakes Drainage Basins Office. It is based on data available as of January 1, 1953, on sources of pollution and treatment facilities employed, and on stream conditions revealed by field surveys made by the Minnesota Department of Health over a period extending from 1939 through 1952. The report also presents information concerning use of water resources, pollution entering water resources and resulting damages, and benefits which may result from pollution prevention and abatement. The report has been limited to known sources of pollution and their effects upon adjacent streams. No attempt has been made to present data on the remaining large number of lakes and streams throughout the basin.

The Public Health Service cooperated in the preparation of this report under the Federal Water Pollution Control Act, Public Law 845, passed by the 80th Congress in June 1948, which requires the Surgeon General of the Public Health Service to cooperate with other Federal agencies, with State and interstate water pollution control agencies, and with municipalities and industries in the preparation or adoption of comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof, and improving the sanitary condition of surface and underground waters. The Act requires that due regard also be given to improvements necessary to conserve the waters for public and industrial water supplies, propagation of fish and aquatic life, recreational purposes, agriculture, and other legitimate uses.

Data and knowledge available in the Department of Health are considered sufficient to permit the evaluation of the pollution problems within the basin.

An effort has been made to present an accurate picture of the stream conditions and the water pollution problems in this basin. This report has been prepared as a step in the cooperative development of an ultimate comprehensive water pollution control program for safeguarding the water resources of the area.

SUMMARY

The area drained by the main stem of the Mississippi and its tributaries above Minneapolis and St. Paul is about 19,800 square miles. The major tributaries to the Mississippi in this area include the Crow Wing, Sauk, Rum, and Crow Rivers.

The economy of the area is based largely upon agriculture and related industries, especially dairy activities. The 1950 census reveals a basin population of about 475,000 with three cities having populations of 10,000 or more. Iron ore mining and processing is an important and growing industry in the northeastern portion of the basin, which contains all of the Cuyuna Iron Range and the western part of the Mesabi Iron Range.

The large number of lakes and streams of the basin provide excellent recreational facilities and the basin includes one of the most important resort regions in the State.

Ninety-six municipalities in the basin have sewer systems collecting the wastes from an estimated 147,500 people. Sixty-three of these communities have sewage treatment works serving 89,000 people.

There are 269 industries in the basin which discharge their wastes directly to the surface watercourses and not to municipal sewers. Sixty-four of these are iron mines and 24 are iron ore processing plants. Fifty, of the 88 iron ore industries which produce inorganic wastes, are known to provide some form of waste treatment before discharge of the waste. Inorganic wastes from the iron mining industry have been responsible for some adverse effects on the streams. There are 181 industries producing organic wastes, most of which are small dairy products or food locker plants.

Municipal wastes are responsible for damages in many sections of the main stem and major tributaries. Canning wastes have caused considerable damage in the Crow River sub-basin. The worst pollution conditions have been considerably improved by the treatment, impoundment, or the complete removal of the offending waste.

Two municipalities, with a population of 26,000, located within the basin use surface water as a source of supply. Minneapolis and St. Paul, with a combined population of 825,000, located just below the basin, also use the basin's surface water for their source of supply. There is a constant danger that untreated sewage being discharged above existing water intakes will reach these municipal water supplies in such concentration that the water treatment plants will be unable to produce a safe, potable water. There is also the danger that taste and odor producing substances introduced into the water by pollution may make it impossible to produce a palatable water.

Ice Harvesting

In many areas of the basin, ice is harvested from the surface during the winter months and stored for summer use.

In numerous places the stream immediately below a community was found to have bacterial pollution of a magnitude exceeding that recommended as safe for bathing purposes.

There are many sources of pollution which adversely affect desirable water characteristics of the streams. In some instances the streams recover from one pollution load before they receive the next, but in other places recovery is incomplete and the pollution load becomes cumulative.

Considerable progress has been made in pollution control within the basin. Most of the pollution sources which were causing serious damage have been eliminated or have had the polluting elements of the waste materially reduced. Some major and many minor pollution problems still remain to be solved.

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CONCLUSIONS

1. The major sources of pollution of the basin waters are the untreated or partially treated sewage and wastes from the municipalities, the organic wastes from the dairy and wood products industries, and the inorganic wastes from the iron ore industries.
2. Sources of organic pollution occur throughout the area but are much more prevalent in the lower portion of the basin. The sources of inorganic pollution are concentrated in the two iron ranges.
3. The most important water uses are domestic water supply, recreation, agriculture, and industrial supply.
4. Municipalities and industries are making substantial progress in the stream pollution control program.
5. Bacterial pollution is serious in many places. Nuisance conditions exist below communities which are discharging untreated sewage to the streams.
6. Existing pollution and nuisances can be controlled by adequate treatment of the raw and partially treated sewage now entering the streams and by proper disposal or treatment of industrial wastes.

PHYSICAL DESCRIPTION

The Upper Portion Upper Mississippi River Basin includes the drainage area of the Mississippi River and its tributaries above the Camden Bridge at the northern edge of Minneapolis. The basin is roughly rectangular in shape, being approximately 100 miles wide and 260 miles long. It contains about 19,800 square miles and lies entirely within Minnesota.

The Mississippi River rises in a small lake named Hernando de Soto. It flows north into Lake Itasca, then circles to the north and east, finally turning and flowing southward to the Gulf of Mexico. The course of the river within the basin resembles a hugh question mark in pattern. At the junction with the Crow Wing River it has flowed 350 miles, yet it is only 75 miles from its source. The upper portion of the river is a slow, meandering stream dropping only 311 feet from Lake Itasca to Brainerd, a distance of 363 miles. Below Brainerd the river falls more rapidly, dropping 490 feet in the 223 miles between Brainerd and Hastings. This steeper gradient provides many power sites, some of which have been developed.

The drainage pattern of the area consists principally of large and small lakes and muskegs, connected by rivers and creeks which weave a network of waterways. The principal tributaries are Leech Lake, Willow, Pine, Crow Wing, Sauk, Crow, Prairie, Elk, and Rum Rivers. The important lakes are Mille Lacs, Leech, Winnibigoshish, Bemidji, and Cass. The first three lakes listed above are the second, third, and fourth largest lakes in Minnesota. Many of the smaller tributaries are completely dry during the summer months except for storm water runoff.

The topography is gently undulating, having long low swells and hollows in the north and smooth outwash plains in the southwest. In some places between the lakes and rivers there are smooth or gently rolling plains, while in other places there are irregular ridges and patches of hills. Erosion by the major streams has exposed portions of the uneven bedrock surface in some places. A maximum land elevation of about 1,200 feet above sea level is found near the headwaters.

The basin is generally covered with blue till, a compressed mixture of sand, clay, and gravel. Most of the top soils, derived from glacial drift, are arable and are underlain by a heavy clay sub-soil. There are numerous large and small old lake plains with rich muck soils throughout the basin. The large amount of peaty material in the muskeg areas is unsuitable for agriculture.

The native vegetation of the basin consists mainly of two types of forest: coniferous in the northern two thirds and hardwoods, mostly oak, in the southern third. Locally there are stands of pine on sandy soils and black spruce and tamarack on moist soils.

Practically the entire basin has been cut over and second growth is quite typical at present. Large expanses of muskeg are common in the northern part. The forest, lakes, and streams with their game and fish afford exceptionally fine recreational resources.

Climatology

The climate of the basin is characterized by relatively cold winters and fairly short, but productive, growing seasons. The average January temperature will range from 4° F. in the north to 14° F. in the south. The corresponding average July temperature ranges from 68° F. to 72° F. The average annual precipitation in the basin varies from 22 inches in the north to 29 inches in the south. Most of this precipitation occurs during the growing season. The average dates of the last killing frost in spring are for the northern section, May 25, and for the southern section, May 10. The corresponding dates for the first killing frost in the fall range from September 20 to September 30.

Hydrology

The flow in the Mississippi River varies widely from year to year and during the year. For instance, the average annual discharge at St. Paul ranged from 1,935 to 17,100 c.f.s. (cubic feet per second) during the period 1933 to 1950. The average flow for 58 years (1892-1950) was 9,424 c.f.s. Mean monthly flows varied from 864 to 4,804 c.f.s. during the dry year of 1934 and 3,883 to 32,600 c.f.s. during the wet year of 1950.

The minimum flow on record, at St. Paul, 632 c.f.s., occurred August 26, 1934, and the maximum known discharge of 107,000 c.f.s., April 21, 1881. The water year of lowest flow was 1934-35 when a discharge of only 820 c.f.s. represented the flow which was exceeded 95 percent of the time. The average flow for the entire month of August 1934 was only 864, or slightly greater than the 95 percent flow of 820. Although the lowest flow on record occurred in August 1934, the normal low flow period occurs during the winter months when a mean flow of about 1,200 c.f.s. for the minimum ten-day period of the year will occur about once in ten years.

Reservoirs on the headwaters of the Mississippi, while constructed primarily for navigation and flood control, have incidentally been of some aid to pollution abatement by augmenting low flows.

The effect of river discharge on the time of flow from upstream points to Minneapolis was shown in Table XX of the Second Annual Report of the Metropolitan Drainage Commission of Minneapolis and St. Paul, published in 1928.

TABLE XX
Showing Effects of the Construction of Dams Upon the Flow
Time in Days in Different Reaches of the Mississippi River
Above St. Anthony Falls

	Distance in Miles	Flow time before Construction and Proposed of Dams	Flow time with Existing and Proposed Dams
Low water stage			
Pokegama to Sandy River	78	3.5	8.5
Sandy River to Brainerd	104	5.0	6.0
Brainerd to Sauk Rapids	72	3.0	8.5
Sauk Rapids to St. Anthony Falls	74	3.5	13.5
TOTAL	328	15.0	36.5
Ordinary stage			
Pokegama to Sandy River	78	2.5	5.5
Sandy River to Brainerd	104	3.5	4.0
Brainerd to Sauk Rapids	72	2.5	7.5
Sauk Rapids to St. Anthony Falls	74	3.0	10.0
TOTAL	328	11.5	27.0
Moderate freshet			
Pokegama to Sandy River	78	2.0	4.0
Sandy River to Brainerd	104	2.5	3.0
Brainerd to Sauk Rapids	72	2.0	6.0
Sauk Rapids to St. Anthony Falls	74	2.0	7.5
TOTAL	328	8.5	20.5

The discharges of the tributary rivers vary widely from season to season and from year to year with many having zero flow at times.

Average, maximum, and minimum flow data for the Mississippi River is given in the following table.

MISSISSIPPI RIVER FLOWS IN
CUBIC FEET PER SECOND*

	Location of River Gage				
	Near Libby	At Aitkin	At Royalton	Near Elk River	At Anoka
Years of Record	20	5	26	35	19
Average Discharge	1,681		3,507	4,937	6,198
Maximum Discharge	16,000	20,000	28,000	39,000	50,700
Minimum Discharge	83	236	254	278	586

*Prepared from data secured from the Geological Survey Water-Supply Papers.

The average flows which occurred on the main stem of the Mississippi River during the River Pollution Survey sampling periods are given below.

MISSISSIPPI RIVER FLOWS IN
CUBIC FEET PER SECOND*

Date of Sample Period	Location of River Gage				
	Near Libby	At Aitkin	At Royalton	Near Elk River	At Anoka
1939 May 4-8	2,200		5,920	9,500	11,350
June 13-15	840		2,560	3,400	4,270
July 11-13	1,003		2,660	3,870	4,730
Aug. 21-23	871		1,340	2,180	2,590
Dec. 18-21	612		1,050	1,540	1,830
1940 Feb. 7-9	400		885	1,070	1,230
1946 Mar. 4-8		1,640	2,730	3,560	4,280
1949 Jan. 10-18		730	1,580	1,840	2,100
1951 Aug. 15-20		2,250	3,560	4,670	6,610
Sep. 19-20					14,800
1952 Apr. 29-May 6		8,350	15,400	21,200	31,000
Aug. 13			12,500		
Aug. 14			12,300		

*Data from the Water-Supply Papers and from unprinted records of the Department of the Interior, Geological Survey.

ECONOMIC DEVELOPMENT

Population

The 1950 population of the basin was calculated to be 475,700 with 35 percent, or 166,570 persons, residing in 46 communities of 1,000 population or more. The 1950 census lists 207 communities in the basin with a total population of 225,900. One hundred and fifteen have populations of less than 500, 45 have between 500 and 1,000, 39 have between 1,000 and 5,000 people, and 8 have more than 5,000 population. The three largest cities are Bemidji with a population of 10,001, Brainerd with 12,637, and St. Cloud with 28,410.

In 1952, there were 96 municipalities in the basin with sewer systems, 63 of which also provided primary or secondary treatment of sewage or had treatment plants under construction. There were also 12 communities which were planning or constructing their first sewer systems. These 12 projects included sewage treatment plants at each place.

The population concentrations in the basin vary widely from a very few people per square mile in the north to several score per square mile in the south. The basin as a whole has a population concentration of 12 persons per square mile.

Agricultural Development

As the virgin timber in the northern portion of the basin was removed and the cutover areas extended, farmers moved in to clear the stumps and carry on mixed farming. Many such areas have developed extensive dairy activities. In other areas, farther south, growing vegetables for canning has become a substantial agricultural activity. Corn is the most important field crop, but considerable quantities of small grains are also grown. Stock watering is a common agricultural use of the waters of the basin.

Industrial Development

Iron ore mining and processing is one of the principal industries in the northeast portion of the basin, which contains all of the Cuyuna Range and a part of the Mesabi Range. The 1952 Mining Directory of Minnesota listed 63 active mines, 36 inactive mines where operations may be resumed on short notice, 67 reserve properties, and 19 exhausted mines which may be reopened for low grade ore or taconite.

Four hundred and twenty million tons of iron ore have been removed from the mines in the basin since operations were started. The basin produced 17,700,000 tons of ore in 1951 and at that time had approximately 210 million tons of high grade ore in known reserves.

There are 29 iron ore processing plants in the basin, including 12 washing plants, 8 washing and Hi-density plants, 2 washing, jigging and Hi-density plants, 1 screening plant, 1 washing and jigging plant, 1 washing, Hi-density and cyclone plant, 1 washing, screening and sintering plant, 2 crushing plants, and 1 crushing and drying plant.

Many of the mines and processing plants use large quantities of water and produce or are potential producers of "red water" wastes which cause objectionable pollution if they enter a watercourse.

Processing dairy products is also a major industrial activity throughout the basin. There are 183 creameries, 54 pasteurization plants, 31 dry milk plants, 11 condensing plants, and 14 cheese plants in the basin. Many of these are located in communities which have municipal sewer systems into which the wastes are discharged. Six cheese plants, 6 dry milk plants, 7 pasteurization plants, and 84 creameries located in communities without sewer systems discharge their wastes directly to the basin's watercourses.

A recent industrial development is the establishment of refrigerated food locker plants. There are 144 of these locker plants in the basin, 73 of which are located in communities with sewer systems and 71 in communities without sewers. A large number of these plants have slaughtering facilities and are sources of pollution.

There are four paper mills in the basin with a combined daily capacity of about 255 tons of ground wood and 375 tons of paper. The chemical pulp needed for paper making is imported from outside the basin. Industrial wastes from these mills are typical ground wood and paper wastes.

The basin also contains numerous other industries with waste disposal problems, such as small meat packing plants, flour mills, breweries, wood products plants, and granite quarries.

Recreational Development

The large numbers of lakes and streams in the basin, particularly in the northern portion, provide excellent recreational facilities and the basin is an outstanding resort region. Summer resort hotels, tourist camps, tourist cabin motels, golf courses, hunting and fishing lodges, and communities of summer residences have been established throughout the basin, notably in the vicinity of Brainerd, Walker, and Bemidji. Many species of fish are found throughout the area, although the low seasonal flows and high temperatures limit game fishing in some of the smaller streams in the southern portion of the basin. Deer are numerous in some areas and small game can be found throughout the basin. Upland

game bird and water fowl hunting is good over the entire watershed area, with plentiful cover for all species in the farm fields, ditches, wilderness, slough, and swamp areas. The value of recreation activities has not been established for this basin but these activities are of major economic importance. The tourist industry is Minnesota's second largest industry. The three leading industries, from an economical standpoint, and in the order of their importance, are agriculture, tourist, and mining.

Income

The average per capita effective buying income for 1951 in the basin calculated from data secured from the May 1952 issue of Sales Management "Survey of Buying Power" was \$943 per annum compared to the national average of \$1,423. The effective buying income within the basin ranged from \$570 per capita in Anoka County to \$1,740 per capita in Hennepin County.

USES OF WATER RESOURCES

Municipal Water Supplies

There are two communities within the basin which use surface water as a source of supply for a combined total of about 26,000 people. St. Cloud takes a daily average of 3 million gallons per day from the Mississippi River with peak withdrawals reaching 5 to 6 million gallons per day. Akeley uses Eleventh Lake as a source for 50,000 gallons per day.

Minneapolis and St. Paul, both located just outside of the basin, are dependent on waters of the basin for their municipal supplies. Minneapolis withdraws 50 to 60 million gallons per day from the Mississippi River for 520,000 people while St. Paul, with a population of 310,000, uses 30 million gallons from the same river.

The other communities in the watershed area obtain their water supplies from underground sources. Wells are used by 115 communities while one community gets its supply from a mine shaft. These 116 places supply 111,000 people with 7.6 million gallons of water per day. See Appendix III.

Future growth and development of communities in the basin may result in increased use of surface water for municipal supplies.

Recreational Uses

The waters of the basin are used extensively for recreational activities, particularly in the northern portion. Fishing, swimming, and boating are all important uses. Hunting, while not a water use, depends upon the game attracted to the area by the water available for its use and convenience.

Testimony offered at a hearing held by the Water Pollution Control Commission at Little Falls indicated considerable game fishing in the river from Little Falls down through the St. Cloud area. An investigation was made by the Minnesota Department of Health in 1951 and covered that portion of the river from Anoka to Camden, an area of growing importance for residential purposes. A total of 324 dwellings was counted on both sides of the river and it was estimated that 70 percent of the occupants owned some form of small boat. Some docks and private beaches were also observed, and interviews with a representative portion of the occupants indicated that approximately 70 percent utilized the river for boating, fishing, irrigation, or a combination of these purposes.



Industrial Water Supplies

Several of the industries obtain process water from surface sources but the majority, especially the food processing industry, utilize existing municipal water supplies or have their own wells. Pollution of surface waters does not appear to have been a factor in the choice of industrial water supply.

The four paper mills use large quantities of water from the Mississippi River. The quality of this water appears to be satisfactory for their use at present, but possible contamination from iron mine wastes is causing considerable concern. Surface waters are also used by the mines and iron ore processing plants. Large quantities are needed but as most of these iron ore industries are in areas where water is in short supply, they are meeting their needs, in many cases, by reuse of water. Most of the iron ore mines and processing plants have tailing ponds or settling basins which are of material benefit to pollution control. Some of these settling basins were constructed primarily for their value as water conservation measures, but they all serve as pollution abatement facilities. Several of the mines rely upon underground sources for their water supply as surface water is not available at all times.

Sewage and Waste Disposal

Another important use of the basin's waters is for the final disposal of municipal and industrial wastes. To the extent the receiving waters are able to assimilate the volume of wastes discharged into them without being adversely affected or damaged for other uses this is a legitimate and economic use of the waters.

Agricultural Use

Stockwatering is a common water use in the basin, and constitutes one of the important agricultural water uses. As a large proportion of the stock in the basin is dairy cattle, it is important that pollution of the waters be kept at a minimum.

Hydroelectric Power

The Corps of Engineers, Department of the Army, has reported on 12 possible dam sites on the main stem above Minneapolis. For the period of record studied and the conditions assumed, the Corps of Engineers reports that these plants may produce about 87 million kilowatt hours of primary power and 314 million kilowatt hours of secondary power annually. Eleven hydroelectric plants are now located in the basin and are using the surface waters to produce about 380 million kilowatt hours per year. Eight of these plants are on the Mississippi River and three are on the tributaries.

POLLUTION DISCHARGED TO BASIN WATERS

Detailed basic data on 365 municipal and industrial sources of pollution are given in Appendices I and II. Appendix I lists municipal sources, giving the name of the community, the number of people served by the sewers, the type of treatment provided, the adequacy of the existing treatment facilities, the municipal pollution abatement needs, and the action that the communities are taking to meet their needs. Appendix II gives the name and location of the industries discharging wastes, the type of industry and the type of waste produced, the type and adequacy of the treatment or pollution control measures provided, the pollution abatement needs, and the action that the industry is taking to meet these needs. Map No. 1 shows the location of the municipal sources of pollution in the basin and Map No. 2 shows the location of the industrial sources of pollution. Table A is a summary of the sources of pollution for which the detailed information is given in Appendices I and II.

TABLE A
MUNICIPAL AND INDUSTRIAL SOURCES OF POLLUTION
January 1953

Source of Pollution	Number of Sources	Population Served by Sewerage System
Municipalities with sewage plants	63	88,962
Municipalities without sewage plants	33	58,475
Industries producing organic wastes*	177	not applicable
Industries producing organic and inorganic wastes*	4	not applicable
Industries producing inorganic wastes*	88	not applicable
TOTAL	365	

*These industrial sources include only those industries that discharge their waste directly to the watercourse and not through a municipal sewer system.

Municipal Sources

As shown in Table A, there are 96 communities in the basin serving a total of 147,437 people that discharge their wastes to the surface waters. Many of the municipal sewers collect wastes from industries located in the community and the total pollutational load of the combined sewage and industrial waste in these communities is much greater than that indicated by the number of persons served by the sewer systems. Sixty-three communities, having a combined

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sewered population of 89,000 (60 percent of the sewered population), are served by municipal sewage treatment works. Thirty-three of the 96 sewered communities of the basin do not have sewage treatment works. These 33 communities serve approximately 58,000 people, or 40 percent of the sewered population, and include eight with populations under 500, seven with populations of 500 to 1,000, eleven with populations of 1,000 to 2,500, two with populations of 2,500 to 5,000, two with populations of 5,000 to 10,000, and one with a population over 25,000.

Industrial Sources

A summary of industrial sources of pollution located outside of municipalities with sewer systems or which do not discharge their waste to a municipal sewer is shown in Table A. These sources are also shown in Table B where they have been listed according to the type of industry and the treatment provided for the wastes. A total of 269 industries discharge their wastes directly to the watercourses. Sixty-four of these are iron mines and 24 are iron ore processing plants which produce inorganic wastes. Fifty of these sources of inorganic wastes are known to provide some type of treatment and only one is known to provide no treatment.

TABLE B
EXISTING INDUSTRIAL WASTE TREATMENT FACILITIES
January 1953

Type of Industry	Number of Plants	Number of Industrial Plants Having		
		Treatment Facilities	No Treatment Facilities	Undetermined Facilities
Creamery or Milk Plant	71	2	0	69
Food Locker	60	0	1	59
Creamery and Food Locker	10	0	0	10
Cheese	10	3	1	6
Condensery or Dry Milk	7	2	0	5
Canning	8	5	2	1
Meat	2	0	2	0
Brewery	1	0	0	1
Vegetable Oil	1	1	0	0
Flour Mill	1	0	0	1
Rendering	3	3	0	0
Paper	4	4	0	0
Pharmaceutical	1	0	0	1
Chemical	2	1	0	1
Ore Processing	24	19	0	5
Iron Mining	64	31	1	32
TOTAL	269	71	7	191





There are 181 industries producing organic wastes, most of which are small dairy products or locker plants which do not contribute large amounts of wastes to the basin's waters. Food product plants and paper mills are the principal contributors of industrial organic wastes, and most of these have provided some waste treatment facilities as shown in Table B. The majority of the small plants create only local pollution problems.

The major sources of industrial pollution have all been determined and their effects on the waters are well understood. Information on several of the smaller sources of industrial wastes has not been secured. An accurate evaluation of their significance would require a separate investigation to determine the degree of pollution in each case.

Surface runoff from farm fields and barnyards contains organic materials which add to the pollution load and may adversely affect the basin waters. Silt, eroded from plowed fields, railroad and highway embankments, and from mine dumps, is another form of pollution that affects all water use.

EFFECTS OF POLLUTION AND DAMAGES TO WATER RESOURCES

Damage to Domestic Water Supplies

Polluted water endangers health. It can carry contagious diseases like typhoid, enteritis, and dysentery. Sewage pollution damages water for use as a source of a domestic supply by creating a bacterial hazard which is a direct threat to the health of consumers who use the surface water directly--for instance, farmers, campers, fishermen, etc. Communities that have modern water treatment plants are generally able to produce a safe water from a bacterial standpoint but occasionally the treatment processes fail to remove all of the bacteria. One slip may bring on an epidemic. Minneapolis, with a modern, well equipped, and technically supervised water filtration plant, experienced a serious typhoid outbreak in 1935. This outbreak is described in the "Report of Investigations of the Typhoid Fever Epidemic--Minneapolis, 1935" by the Minnesota Department of Health. The Minneapolis outbreak of 1935 with 213 cases of typhoid fever and 7 deaths appears to have occurred when water pumped to consumers from one of the municipal filtration plants carried little or no residual chlorine. This experience demonstrates the danger of a contaminated water supply source even though a well operated, modern water filtration plant is provided by the municipality. Extremely heavy bacterial loadings may require chlorine dosages of such magnitude that chlorinous tastes are produced. The result is a water which, though safe from a bacterial standpoint, is unpalatable because of objectionable tastes. Some types of pollution introduce taste and odor producing substances which are difficult or impossible to remove by available water treatment facilities.

Damages to Recreational Water Use

Bacterial pollution, introduced by the discharge of sewage to the basin waters, damages recreational use by creating a hazard to bathers and others who come in contact with the water. There is an additional damage to recreational use in localized areas because the presence of visual pollution discourages such use. Pollution, especially "red water" from mining activities, is reported to have affected recreational use of the waters in some areas. Pollution prevents the development of recreational facilities in places where the water quality has been allowed to deteriorate. If recreational use is to continue and increase, the waters must be kept free of pollution that is harmful to health or detrimental to aquatic life and aesthetic values.

Damages to Fish and Aquatic Life

Sport fishing has been curtailed in some places because of fish kills of considerable magnitude. In other areas, pollution

has driven fish from the waters by destroying their food or by creating an undesirable habitat. A biological survey made in 1940 showed that pollution was so severe in the South Fork of the Crow River at a point $1\frac{1}{2}$ miles below Watertown that over 88 percent of the bottom aquatic organisms were of the polluttional type not considered to be satisfactory fish food. The condition of the river has improved since the canning plant which was contributing a large portion of the pollution load (P.E. of 7,000 in 1937) began disposing of its waste by irrigation and pollution no longer reaches the watercourse from this source. Repeated fish kills occurred on the South Fork of the Crow River prior to the installation of this irrigation system. Four of the more recent fish kills on the South Fork are: (1) August 21, 1942 - a fish kill occurred between Delano and Watertown; depletion of oxygen was suspected. (2) September 4, 1946 - a fish kill occurred between Delano and Watertown. The dissolved oxygen concentration in the river was 0.0. Oxygen depletion was attributed to the waste from the corn packing plant at Watertown. (3) March 6, 1947 - a fish kill occurred at Delano. (4) July 1948 - a fish kill occurred at Hutchinson. Complete dissolved oxygen depletion was found.

On October 1, 1947, there was a total fish kill in the North Fork of the Crow River which was attributed to pollution from creamery waste. Periodic fish kills occurred in Sucker Creek until 1941, at which time the Cokato sewage treatment plant was placed in operation. No fish kills have been reported since that time. There was a fish loss in Pike Lake, Mounds View Township, Ramsey County, on July 24, 1939, which was attributed to pollution entering the lake.

Other Polluttional Damages

Industrial water used by the paper mills must have a very low iron content or damage to paper quality will result. The increasing "red water" pollution from the water discharged from the iron mines and iron ore processing plants is endangering the water supplies used by the paper mills in the same area.

Pollution of sewage origin may contaminate waters from which ice is harvested and endanger the health of the people using the ice for direct cooling of beverages or other foods.

Field Studies of Pollution and Pollution Effects

The pollution entering the water used as a source for municipal water supply or used for bathing is of grave concern to those officials responsible for the health of the public in the affected area. Observations of the rivers at specific points have been made by the Minnesota State Department of Health from time to time as local situations required. The first general observations by the Department of Health were made on the main stem of the Mississippi River in 1928 in connection with an investigation

the river from Minneapolis to La Crosse. Information on these observations is contained in the report of the investigation published in the Second Annual Report--Metropolitan Drainage Commission, 1928.

Analytical data on the main stem of the Mississippi River above Minneapolis were first collected in 1930. In 1939 a river study was initiated and a series of sampling stations established on the basis of these earlier observations at points where changes in water quality were indicated.

This study included the main stem of the Mississippi River from the Camden Bridge in Minneapolis to a point above Brainerd; the Crow River as far as Hutchinson on the South Fork and to a point ten miles above Jewett Creek on the North Fork, Buffalo Creek to Glencoe; and the Rum River in its entirety. One survey was also made on the Sauk River. The location of sampling stations is shown on Map No. 4.

Sampling stations used for the study were selected after careful preliminary observations of the condition of the rivers. As the study progressed, other stations were added and some of the original stations abandoned as the data indicated the need for more detailed coverage in some areas and less coverage in others. Twenty-nine sampling stations were used on the main stem of the Mississippi River, 21 on the Rum River, 7 on the main stem of the Crow River, 9 on the South Fork of the Crow River, 10 on the North Fork of the Crow River, 4 on Buffalo Creek, and 21 on the Sauk River.

A complete detailed list of these sampling stations and their locations is given in Appendix IV.

The laboratory procedures employed in the analyses of the samples were in accordance with "Standard Methods for the Analysis of Water and Sewage," 8th and 9th Editions, 1936 and 1946. The most probable numbers of coli-aerogenes bacteria were determined by progressive dilutions of the sample in lactose broth with gas inner tubes. The incubation period was for 24 and 48 hours at 37° centigrade. The positive tests were confirmed on eosin-methylene-blue plates. The biochemical oxygen demand test included initial dissolved oxygen determinations, proper dilutions, and 5-day incubation at 20° centigrade. The Alsterberg modification of the Winkler method for dissolved oxygen was employed in these studies.

Biological samples for determination of plankton included both net plankton and centrifuge nanno-plankton samples. The procedures employed in collecting, concentrating, and microscopic examination of these plankton samples were in accordance with Part V of the Standard Methods for the Examination of Water and Sewage.

Biological samples for determination of life on the stream bottoms were obtained by hand dredge. On sand bottoms, the Peterson dredge was used whereas for mud bottoms the lighter Ekman dredge was employed. The procedures employed in screening and examination of the bottom samples as well as a discussion of the interpretation of the results are also given in Standard Methods.

21-a



LOCATION MAP

UPPER PORTION
UPPER MISSISSIPPI RIVER BASIN
LOCATION OF SAMPLING STATIONS
U. S. DEPARTMENT OF
HEALTH EDUCATION AND WELFARE
Public Health Service
DIVISION OF WATER POLLUTION CONTROL
MAP NO. 4

Discussion of Data Collected During Study

Chemical Characteristics - The chemical characteristics of the water varied only slightly throughout the section of the Mississippi River included in this study. The variations reflected in the results of the laboratory analyses are shown in the Summary Tables I and II and Figure No. 1, which were prepared from the detailed tabulations of individual analyses included in Appendix V, Tables 1 through 4. The tables in the appendices give the analyses of the individual sample, the date the sample was collected, and the river flow at the gaging stations above the sampling points.

The volume of river flow evidently has little effect on the chemical characteristics of the water since no significant correlation was found between flows, pH, color, turbidity, or alkalinity. There were only slight changes in alkalinity and pH in the Mississippi River below the junction with tributary streams even though these two characteristics of the tributary streams were quite different from those of the main stem. Color and turbidity changes in the Mississippi River had no apparent relationship to the color or turbidity brought in by the tributaries.

The chemical characteristics of the waters of the tributaries were found to vary over much wider ranges than those of the main river. The results of the chemical analyses of these waters are summarized in Tables 8, 10, and 12 of Appendix V. Apparently the chemical characteristics of the tributary waters were not greatly affected by the wastes entering them since no significant correlation could be established between changes in chemical composition and known sources of pollution.

Dissolved Oxygen and Biochemical Oxygen Demand - Results of D.O. (dissolved oxygen) and 5-day B.O.D. (biochemical oxygen demand) analyses for the Mississippi River are tabulated in Appendix V, Tables 5 and 6, and are summarized in Table No. III. The D.O. data has been plotted in Figure 2.

There was a slight but noticeable increase in the 5-day B.O.D. below Brainerd and Little Falls, at Sartell, and below St. Cloud, Monticello, Elk River, and Anoka. With the volume of water available in the river the oxygen demand in p.p.m. of the organic material in that water as measured by the 5-day B.O.D. would not be expected to be high. It was found that the presence of oxygen consuming material in the Mississippi River as indicated by the B.O.D. did not depress the average D.O. below safe limits. The lowest average D.O. at any station was 6.3 p.p.m., which is well above 4.0 p.p.m., the limit generally accepted as necessary to support game fish. The D.O. was found to be below 5.0 p.p.m. in only 5 of the 233 Mississippi River samples analyzed. During the survey of July 1939, a D.O. concentration of 4.0 p.p.m. was found in the river pool above the sources of pollution at Brainerd. At the first sampling station below Brainerd, the D.O. was 3.8 p.p.m. Twenty-five miles below Little Falls the D.O. was 4.2 p.p.m. Between these two points and

TABLE I
SUMMARY OF VARIATIONS IN ANALYTICAL DATA
MISSISSIPPI RIVER SURVEY
1939 - 1952

Sample Station:	Turbidity p.p.m.				Color p.p.m.			
and Community	No. of	Aver-	Max-	Min-	No. of	Aver-	Max-	Min-
	Samples	age	imum	imum	Samples	age	imum	imum
M-154	2	8	10	5	2	29	30	27
M-132	9	7	15	2	9	43	100	20
Brainerd								
M-130	9	10	20	1	9	57	120	20
CW-1	8	4	5	1	8	26	50	16
M-116	2	6	8	4	2	25	25	18
M-108	10	6	19	2	9	45	100	15
M-105	1	-	28	28	0	-	-	-
M-102	10	7	21	2	9	45	95	16
Little Falls								
M-100	9	9	19	2	9	48	100	15
M-99	1	-	28	28	0	-	-	-
M-85	2	5	6	4	2	26	35	17
Royalton								
M-75	10	9	35	2	9	45	40	16
M-70	3	6	8	5	3	27	40	17
Sartell								
M-69	3	7	10	4	3	26	35	18
S-0	10	7	15	2	9	28	40	16
M-68	10	11	35	2	9	45	90	15
Sauk Rapids								
M-66	6	6	8	2	6	40	75	15
Saint Cloud								
M-63	8	5	7	2	8	42	90	20
M-60	2	5	6	4	2	26	35	16
M-53	8	5	8	2	8	45	90	16
M-38	2	2	3	1	2	25	35	15
Monticello								
M-37	6	5	8	1	6	49	80	20
M-36	2	5	6	4	2	26	35	17
M-27	2	4	6	2	2	25	35	14
Elk River								
M-26	8	7	10	2	8	41	75	15
C-0	7	25	80	2	7	50	100	16
M-14	8	7	15	2	8	41	80	13
R-0	8	7	12	3	8	50	90	16
Anoka								
M-13	6	7	12	1	7	48	90	15
CC	1	-	4	4	1	-	21	21
M-8	8	8	14	3	8	43	80	16
M-6	3	7	13	3	3	27	40	17
RC	2	6	10	2	2	35	50	20
M-1	3	6	9	2	3	30	50	16
M-0	8	9	17	2	8	43	80	16

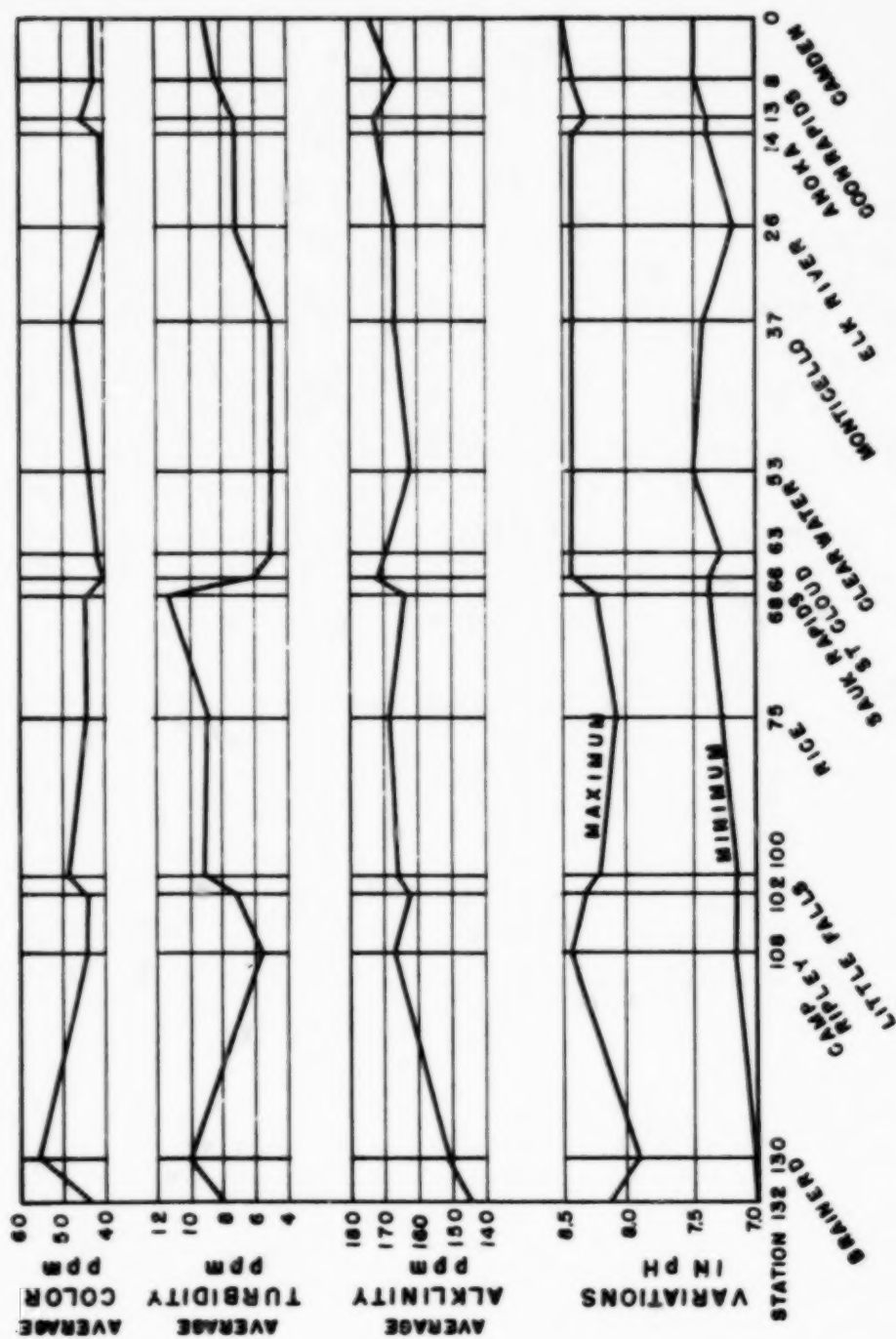
TABLE II
SUMMARY OF VARIATIONS IN ANALYTICAL DATA
MISSISSIPPI RIVER SURVEY
1939 - 1952

Sample Station:	Alkalinity p.p.m.				pH			
and Community :	No. of:	Aver-:	Max-:	Min-:	No. of:	Max-:	Min-:	
	Samples:	age :	imum:	imum:	Samples:	imum:	imum:	imum:
M-154	2	165	170	168	2	-	7.4	7.3
M-132	8	142	200	82	9	7.6	8.1	7.0
Brainerd								
M-130	8	149	220	80	9	7.5	7.9	7.0
CW-1	7	209	260	180	8	8.1	8.4	7.3
M-116	1	-	180	180	2	-	7.7	7.6
M-108	8	166	220	110	10	7.8	8.4	7.2
M-105	0	-	-	-	1	-	7.4	7.4
M-102	8	161	230	100	10	7.8	8.3	7.2
Little Falls								
M-100	8	165	220	100	9	7.8	8.2	7.2
M-99	0	-	-	-	1	-	7.9	7.9
M-85	1	-	180	180	3	-	7.8	7.2
Royalton								
M-75	8	169	230	110	10	7.7	8.1	7.3
M-70	2	180	180	180	3	-	8.0	7.4
Sartell								
M-69	2	180	180	180	3	-	8.4	7.2
S-0	8	211	280	170	10	7.7	8.4	7.4
M-68	8	163	220	110	10	7.8	8.2	7.4
Sauk Rapids								
M-66	5	172	210	150	6	7.9	8.4	7.4
Saint Cloud								
M-63	7	169	215	130	8	8.0	8.4	7.3
M-60	1	-	190	190	2	-	8.1	7.5
M-53	7	161	190	110	8	8.0	8.4	7.5
M-38	1	-	190	190	2	-	8.2	7.4
Monticello								
M-37	6	167	200	120	6	8.2	8.4	7.4
M-36	1	-	180	180	2	-	8.1	7.5
M-27	1	-	180	180	2	-	8.2	7.4
Elk River								
M-26	7	167	190	130	8	8.1	8.4	7.2
C-0	6	257	360	210	7	8.2	8.4	7.6
M-14	7	173	200	120	8	8.2	8.4	7.4
R-0	7	171	200	120	8	8.0	8.3	7.4
Anoka								
M-13	7	174	200	150	8	8.0	8.3	7.4
CC	1	-	170	170	1	-	7.5	7.5
M-8	7	167	200	130	7	8.1	8.4	7.5
M-6	2	185	200	170	3	-	8.0	7.9
RC	2	220	220	220	2	-	7.6	7.4
M-1	2	195	200	190	3	-	8.2	7.5
M-0	7	174	200	130	8	8.0	8.5	7.5

TABLE III
SUMMARY OF VARIATIONS IN ANALYTICAL DATA
MISSISSIPPI RIVER SURVEY
1939 - 1952

Sample Station: and Community	Biochemical Oxygen Demand p.p.m.				Dissolved Oxygen p.p.m.			
	No. of Samples	Average	Maximum	Minimum	No. of Samples	Average	Maximum	Minimum
M-154	1	-	3.0	3.0	2	6.3	6.3	6.3
M-132	3	1.8	2.4	1.5	10	7.1	9.5	4.0
Brainerd								
M-130	3	6.1	12.0	1.2	10	6.8	8.3	3.8
CM-1	2	1.2	1.5	.8	9	8.4	10.8	6.2
M-116	3	1.0	1.3	.9	3	7.4	7.8	6.9
M-108	5	1.3	2.4	.2	11	7.5	10.8	5.5
M-105	2	.9	1.0	.7	1	-	5.7	5.7
M-102	5	1.1	1.8	.4	11	6.7	8.0	4.0
Little Falls								
M-100	2	3.4	4.7	2.1	10	7.0	8.1	5.2
M-99	2	2.2	3.5	.9	1	-	6.0	6.0
M-85	5	1.7	4.4	.6	4	6.7	7.5	6.0
Royalton								
M-75	5	1.2	1.7	.7	11	6.9	8.5	4.2
M-70	3	3.7	8.2	1.1	4	7.0	8.3	5.3
Sartell								
M-69	3	1.4	1.7	1.1	4	7.5	8.9	5.3
S-0	5	1.6	2.5	.5	11	8.5	11.2	6.3
M-68	5	1.6	1.7	.5	11	7.7	8.8	6.0
Sauk Rapids								
M-66	3	.9	1.3	.3	5	7.2	8.1	5.8
Saint Cloud								
M-63	2	.9	1.1	.8	9	8.5	10.0	6.4
M-60	3	1.4	2.7	.7	3	8.5	8.9	8.2
M-53	3	1.3	2.3	.8	9	7.7	8.5	5.2
M-38	3	1.6	2.1	.9	2	8.4	8.8	7.9
Monticello								
M-37	0	-	-	-	7	8.7	10.4	6.1
M-36	3	1.9	4.8	1.3	3	8.4	8.9	7.6
M-27	3	1.2	1.5	1.0	3	8.2	8.7	7.6
Elk River								
M-26	3	1.8	2.6	1.0	9	8.5	10.5	7.3
C-0	3	3.4	6.4	1.2	8	8.0	11.8	2.0
M-14	3	1.5	1.8	1.0	9	7.5	9.3	6.0
R-0	3	2.2	2.4	2.0	4	9.4	11.6	7.0
Anoka								
M-13	2	2.2	2.2	2.1	8	7.8	8.9	7.2
CC	1	-	1.0	1.0	2	8.9	10.0	7.7
M-8	3	1.9	2.2	1.6	9	7.8	8.8	5.9
M-6	3	1.3	1.4	1.3	4	8.5	9.4	7.8
RC	1	-	1.0	1.0	3	8.9	10.8	7.2
M-1	3	1.8	2.1	1.4	4	8.5	9.8	7.9
M-0	3	1.5	1.8	1.1	9	8.1	9.6	6.9

25-a

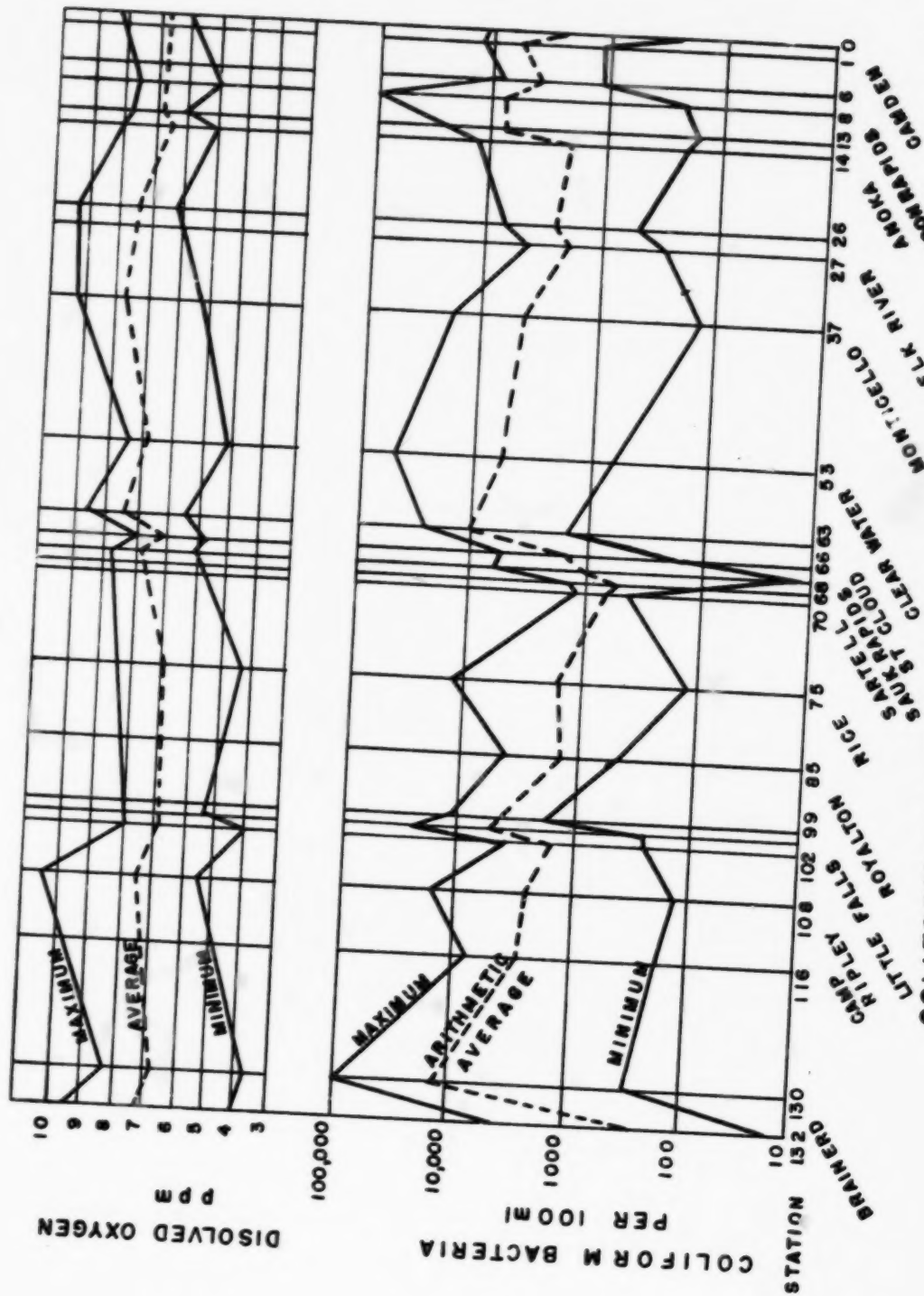


CHEMICAL CHARACTERISTICS OF RIVER WATER

MISSISSIPPI RIVER SURVEY 1939-52

FIGURE 1

25-6



COLIFORM BACTERIA AND DISSOLVED OXYGEN
 MISSISSIPPI RIVER SURVEY 1939-52

FIGURE 2

at the rest of the sampling stations the D.O. was above 5.0 p.p.m. during this same survey, but it was lower at most of the sampling stations than that found during the other 10 surveys. Two other low D.O. values occurred in February 1940, both above sources of pollution.

The average 5-day B.O.D. of the water discharged into the Mississippi River by the tributary streams was higher than the 5-day B.O.D. found in the Mississippi in three instances and lower in one instance. In three cases the average D.O. at the mouth of the tributary streams was higher than the average D.O. in the Mississippi River, but that at the mouth of the Crow River was slightly lower.

The results of the B.O.D. and D.O. analyses made on the waters of the tributaries are summarized in Tables 8, 10, and 12 of Appendix V. An occasional high 5-day B.O.D. value was found in the Rum and Sauk Rivers. High 5-day B.O.D. values were also found in the Crow River and its South Fork during the 1948 survey. These high values in the South Fork reflected pollution originating at a cannery in Watertown. This plant now disposes of all its wastes to irrigation and none reach the river.

Low dissolved oxygen content and at times no oxygen was found in the Crow River and its South Fork. During one survey no oxygen was present at several of the stations. The data from samples collected below Watertown were obtained before the canning wastes originating at Watertown were completely removed from the river and do not reflect the present condition of that portion of the stream.

The average dissolved oxygen found in the Rum River was 4.5 p.p.m. or above at every sampling station. However, Station R-0, at the mouth of the Rum River, was the only station where the D.O. did not drop below this figure at least once during the study. The minimum D.O. was found to be 4.0 p.p.m. or above at only four of the sixteen stations where more than one sample was collected. The D.O. at eleven of the stations was found to be 2.1 p.p.m. or lower at least once during the study.

Coliform Bacteria - The effects of the discharge of untreated sewage or inadequately treated plant effluents to the Mississippi River are more readily seen in coliform determinations than in chemical or oxygen demand tests. Below each municipality, the coliform density as measured by the most probable number of organisms per 100 ml. (M.P.N.) increased sharply. See Summary Table IV and Figure No. 2.

For example, the average M.P.N. for the first six survey runs increased from 25 at Station M-132 above Brainerd to 13,800 at Station M-130 below Brainerd. The Brainerd sewage treatment plant was placed in operation in 1941. The survey made in 1946 showed an increase in coliform density from 79 above Brainerd to 1,845 below

TABLE IV
SUMMARY OF MOST PROBABLE NUMBER OF COLIFORM BACTERIA PER 100 ml. (MPN)
MISSISSIPPI RIVER SURVEY
1939 - 1952

Sample Station and Community:	: Maximum: MPN	: Arith-: Ave. : MPN	: Minimum: MPN	: Number of Samples	: Number of Samples	: Number of Samples	: Number of Samples	: Number of Samples	: Number of Samples
				: 1,000:under:1,000:over:	: 2,500:under:2,500:over:	: 5,000:under:5,000:over:			
M-154	1,600	1,070	540	1	1	0	2	0	2
M-132	2,200	220	5	1	15	0	16	0	16
Brainerd									
M-130	92,000	13,430	330	15	3	9	9	9	9
CW-1	920	280	7	0	11	0	11	0	11
M-116	7,800	3,350	200	4	3	4	3	2	5
M-108	16,000	2,580	130	11	14	7	18	4	21
M-105	2,700	1,740	780	1	1	1	1	0	2
M-102	3,500	1,550	230	17	12	5	24	0	29
Little Falls									
M-100	35,000	5,620	260	21	3	13	11	7	17
M-99	13,000	4,910	2,000	6	0	5	1	1	5
M-85	3,500	1,570	450	7	4	1	10	0	11
Royalton									
M-75	13,000	1,800	130	8	22	6	24	3	27
M-70	1,100	700	450	1	3	0	4	0	4
Sartell									
M-69	1,300	500	200	1	6	0	7	0	7
S-0	13,000	2,530	240	7	6	4	9	1	12
M-68	7,000	1,150	45	10	18	3	25	2	26
Sauk Rapids									
M-66	5,400	1,660	220	7	5	3	9	1	11
Saint Cloud									
M-63	24,000	10,040	1,700	14	0	13	1	9	5
M-60	16,000	10,100	6,400	3	0	3	0	3	0
M-53	54,000	6,550	790	12	1	4	9	4	9
M-38	17,000	6,300	790	2	1	1	2	1	2
Monticello									
M-37	16,000	4,830	130	8	2	5	5	2	8
M-36	160,000	85,100	3,300	3	0	3	0	2	1
M-27	4,900	2,170	330	7	2	2	7	0	9
Elk River									
M-26	7,900	2,730	540	12	3	7	11	2	16
C-0	3,500	1,650	23	7	2	1	8	0	9
M-14	13,000	2,390	230	13	13	7	19	3	23
R-0	16,000	4,200	490	11	3	7	7	2	12
Anoka									
M-13	24,000	7,620	170	14	3	9	8	7	10
CC	4,900	1,940	23	3	2	2	3	0	5
M-8	92,000	8,630	230	12	6	7	11	4	14
M-6	7,900	4,540	1,300	5	0	3	2	3	2
RC	1,700	970	200	3	2	0	5	0	5
M-1	13,000	5,700	1,300	5	0	3	2	2	3
M-0	13,000	2,160	130	13	5	3	15	1	17

Brainerd. On each of the next two surveys one of the samples taken below Brainerd was collected on the east side of the river where the sewage plant effluent was channeling and had not mixed with the river flow. For this reason, these samples do not represent river conditions and the effect of Brainerd's sewage on the river water cannot be determined from them. During the survey made in 1952, the Brainerd sewage treatment plant was being by-passed because of previous flood damage and the coliform density increased from 200 above Brainerd to 92,000 below.

At Little Falls the average M.P.N. increased from 1,550 above the city to 5,400 below. This average does not include one sample, with a M.P.N. of 240,000, that was taken on the west side of the river where the waste from the paper mill was channeling and was not considered a representative river water sample. At St. Cloud, a M.P.N. increase from 1,150 to 10,040 occurred. The increase at Monticello is shown by Summary Table IV to be from a M.P.N. of 6,300 above to 85,100 below, but these averages represent only three samples from above and three from below Monticello. A very slight increase from 2,170 to 2,730 occurred in the M.P.N. at Elk River, and an increase from 4,200 to 7,620 was found at Anoka. Recovery in the river was evident below each source of pollution, but only three stations on the river and two stations in the lower reaches of the tributaries had average coliform bacterial concentrations of less than 1,000 per 100 ml.

Results of the analyses of each sample taken during the years 1939 through 1952 are tabulated in Appendix V, Table 7.

The Public Health Service has established safe permissible limits of raw water pollution which are consistent with the production of potable water meeting given standards of bacterial quality.

In order to deliver water conforming to the Public Health Service standards for drinking water these raw water limits expressed in terms of B. coli numbers have been found to be as follows for the average water purification system of the type and degree of elaboration indicated:

<u>Raw water coliform bacterial content</u>	<u>Type and degree of treatment required</u>
1. Averaging not more than 50 per 100 ml. in any one month.	Simple chlorination
2. Averaging not more than 5,000 per 100 ml. in any one month and exceeding this number in not more than 20 percent of monthly samples.	Rapid sand filtration with post-chlorination

<u>Raw water coliform bacterial content</u>	<u>Type and degree of treatment required</u>
3. Averaging not more than 5,000 per 100 ml. in any one month but exceeding 5,000 per 100 ml. in more than 20 percent of samples and not exceeding 20,000 per 100 ml. in more than 5 percent of samples.	Rapid sand filtration with pre- and post-chlorination combined.

Twenty thousand bacteria per 100 ml. in no more than 5 percent of the samples for any one month represent the maximum safe limit for pre-chlorination or equivalent treatment.

Waters failing to meet the above requirements are considered by the Public Health Service as unsuitable for use as a source of water supply unless they can be brought into conformance with these requirements by means of prolonged preliminary storage or some other measure of equal permanence and reliability.

From a practical standpoint, it has been observed that any general source of raw water supply showing an average coliform density exceeding 5,000 per 100 ml. not only imposes an excessive bacterial loading on the average filtration plant but appears to be generally unsuitable in other respects for producing water of satisfactory quality.

Bacterial quality for bathing waters has not been definitely established but experience apparently demonstrates that, if the monthly arithmetical average M.P.N. does not exceed 1,000, if no more than 20 percent of the samples exceed 1,000 in any one month, and if the M.P.N. does not exceed 2,400 on any one day, many areas may be judged suitable for bathing.

Table IV shows the number of samples at each station which had coliform bacteria concentrations under 5,000 per 100 ml. and also the number with 5,000 or over. Tabulations for M.P.N.'s of 1,000 and 2,500 are also included.

Coliform bacteria content of 5,000 or more per 100 ml. was found in 78 of the 453 samples analyzed. However, only seven of these were samples collected from the three stations which represent the raw water supplies of St. Cloud, St. Paul, and Minneapolis. Of 28 samples collected from the station immediately above St. Cloud only two had M.P.N.'s exceeding 5,000 and these were 5,400 and 7,000. Three of the five samples representing the raw water at the St. Paul river intake had M.P.N.'s of 5,400, 6,400, and 7,900. Two of the five river samples representing the raw water supply of Minneapolis had M.P.N.'s of 9,200 and 13,000.

The maximum bacteria concentrations at these three stations fall within the safe limits for raw water supplies set forth above but the average concentration at the station at Minneapolis is 5,700 slightly above the recommended average of 5,000 for any one month.

Additional bacteriological data on the Minneapolis raw water supply furnished by the Minneapolis Water Department Laboratories for the years 1941, 1942, and 1952 (Appendix V, Table 13) show a significant increase in the bacterial concentrations over a 10-year period. The average M.P.N. of 58 samples collected in 1941-1942 was 2,380, with a low of 260 and a high of 9,200. In 1952 the average of 55 samples was 5,190 with a range of 450 to 22,000. The corresponding river flows for these sampling periods were approximately 6,200 c.f.s. in 1941-1942 and 12,400 c.f.s. in 1952. The increase in M.P.N. reflects the large population growth in upstream communities which discharge raw or inadequately treated sewage to the Mississippi River and its tributaries, and imposes an increasing burden upon the water treatment facilities of Minneapolis and St. Paul.

Data collected show that the bacteria concentrations can and do fluctuate over wide limits at any one sampling station. There is always the constant danger that some of this sewage pollution will reach one of the municipal water supply intakes in such concentrations that the water treatment plant will not be able to produce a safe, potable water. If this happens it will threaten the health of those dependent upon that water supply.

At all of the 34 stations on the Mississippi River at least one sample had a M.P.N. of over 1,000. Using a M.P.N. of 2,400 as a standard for the maximum safe limit for bathing, the water at 29 of the stations was found to be unsafe at least 10 percent of the time, at 25 stations it was unsafe 20 percent of the time, and at 20 stations the water was found to be unsafe 30 percent of the time. More than one half of the water samples collected at 13 (over one third) of the stations indicated that the water was unsafe for recreational use, especially bathing. Station CW-1, located on the Crow Wing River above its confluence with the Mississippi River, was the only station where the M.P.N. of coliform bacteria was within the desirable safe limits for normal recreational use, bathing in particular, at all times.

Results of the bacteriological analyses of the samples collected on the Crow River and its tributaries are given in Table 11 of Appendix V. The M.P.N. increased sharply from an average of 630 at Station CS-151 above Hutchinson to an average of 142,000 at Station CS-150 below. This increase indicates a serious pollution condition resulting from the discharge of inadequately treated municipal sewage into a small stream of limited dilution capacity. The river recovered from this pollution to the extent that at Station CS-78 the average M.P.N. was 3,500. At Station CS-77, below Lester Prairie, the average M.P.N. increased to 6,500. At Station CS-59, just above Watertown, the average M.P.N. was 2,500

while at Station CS-58, one-fourth mile below the sewer outlet, an average M.P.N. of 402,000 was found indicating extremely heavy sewage pollution. This latter value includes one sample, collected September 1939, with a M.P.N. of 1,600,000 and one sample, collected January 1940, with a M.P.N. of 670,000. The Watertown sewage treatment plant was reported as being by-passed in August 1940, and it is possible that the plant was also out of operation when the two high M.P.N. values were secured. If these two results are not included, the average M.P.N. at the station below Watertown would have been 37,000, still a relatively high value. The river gradually recovered from this pollution and at the junction of the Crow River with the Mississippi River the average M.P.N. in the Crow was only 3,300.

The North Fork of the Crow River was found to be a fairly clean stream from a bacteriological standpoint until it reached Station CN-7 one-half mile below Kingston. The M.P.N., which was 490 at Station CN-8 nine miles above Kingston, increased to 9,200 at Station CN-7 one-half mile below Kingston. Buffalo Creek was grossly polluted (average M.P.N. 64,000) at Station B-92 below Glencoe but recovered fairly rapidly and had an average M.P.N. of 5,300 before it entered the South Fork of the Crow River.

The Rum River was found to be a clean stream, bacteriologically speaking, until it reached Station R-110 just below Milaca. See Table 9 of Appendix VI. At that point the average M.P.N. value jumped from 400 to 18,000. This result is attributed to the discharge of untreated sewage into the river a short distance above this station. The river recovered from this pollution by the time it reached Princeton, which discharges inadequately treated sewage into the river. At Station R-78 just below Princeton the average M.P.N. was found to be 43,000 while at Station R-80, only two miles above, the average M.P.N. was 1,000. The river again recovered with the average M.P.N. dropping to 1,300 just above Cambridge. Neither Cambridge nor the State School and Hospital has sewage treatment facilities. Both discharge raw sewage into the Rum River. The resulting gross pollution was indicated by a M.P.N. value of 42,000. The river recovered sufficiently to reduce the average M.P.N. to 700 by the time it reached Station R-2 located two miles above the confluence with the Mississippi. Additional bacterial pollution is picked up in the next two miles as the river passes the State Hospital and flows through Anoka. This caused the average M.P.N. to increase to 2,300 by the time the river reached the Mississippi.

The survey made on the Sauk River indicated the major sources of pollution to be Melrose, Richmond, Cold Springs, and Rockville. The results of the analyses of the samples collected during this survey are tabulated in Table 12 of Appendix V.

Biological Survey Data

Plankton sampling of the surface waters was restricted to only a few of the sampling stations because of limited time and personnel. The stations selected were M-0, M-66, M-132, S-0, and CW-5 for the Mississippi River; R-0, R-1, R-7, and R-141 for the Rum River; and C-1, CN-23, and JS-34 for the Crow River. The description of these sampling stations appears in the appendices. It will be noted that the three stations on the Mississippi River proper and the stations on the Crow and Rum Rivers were not immediately below the major sources of pollution. In each instance the self-purification processes of the stream had progressed far enough, at the points sampled, to provide adequate concentrations of dissolved oxygen. Settleable solids had largely dropped out, yet the dissolved nutriment from previous pollution was evidently sufficient to produce heavy plankton growths.

The plankton at Station M-132 indicated a typical lake plankton rich in algae, diatoms, and protozoans. Plankton collected at Stations M-66 and M-0 contained an abundance of diatoms and blue-green algae, most of which are capable of producing tastes and odors in drinking water when in great abundance. The Crow Wing and Sauk River stations were sampled for plankton only once. The Crow Wing plankton was typical of a normal stream. The Sauk River sample indicated a rich plankton population which contained certain blue-green algae indicative of pollution. The plankton in the Crow and Rum Rivers was rich both in quantity and quality. This was attributed to the sluggishness of the stream and the fertilizing effect of previous pollution.

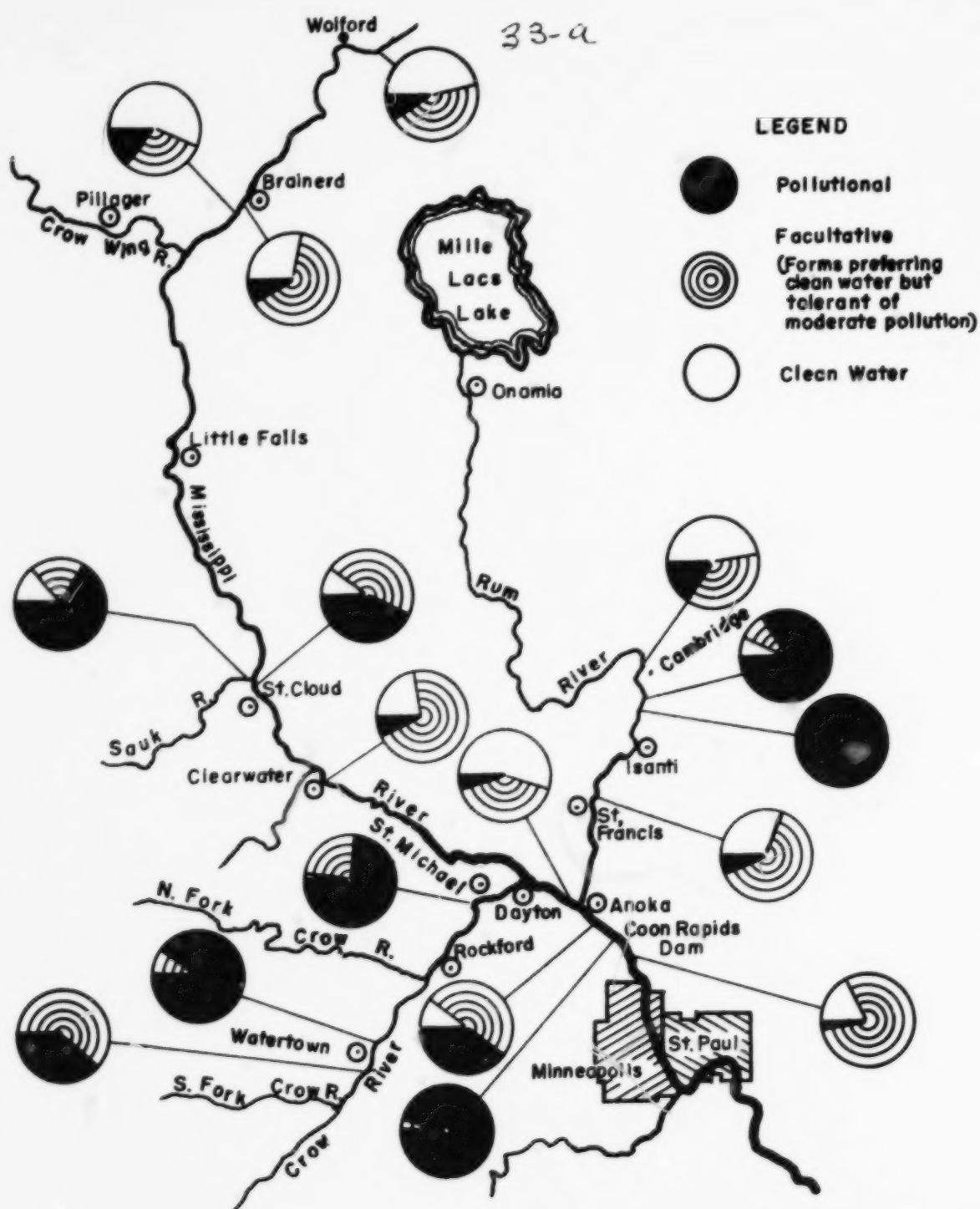
Bottom fauna samples were taken at more stations than were plankton samples. The location of these sampling stations and the results of the analyses are shown by "pie diagrams" in Figure 3. The bottom fauna at Station M-154 were characteristic of swift, clean streams. At Station M-130 below Brainerd, bottom samples from the main channel contained numerous pieces of bark and wood and had a large percent of facultative organisms indicating moderate pollution. A sample collected from the west side of the river about one quarter of a mile below Station M-130 indicated a higher percentage of clean forms than was found upstream.

Figure 3 indicates a polluted condition in the Sauk River. Large numbers of the small crustacean *Hyalella azteca* feeding upon decaying leaves and other organic matter caused the percentage of pollutional forms to exceed the percentage of facultative or cleaner forms. However, there was a wide variety of forms and it was concluded that the bottom was relatively clean and well-aerated. At Station M-66 the major portion, by numbers, of bottom dwelling organisms was facultative forms. These samples contained wood fibers and bark fragments from the paper mills upstream. Thirteen miles downstream at Station M-53 both clean water and facultative organisms had increased in numbers and pollutional organisms had decreased, indicating partial recovery of the stream. At Station

M-14, forty miles further downstream, bottom fauna indicated much improved conditions with clean-water organisms in the majority. This station was six miles below the confluence with the Crow River, which discharges highly polluted water into the Mississippi as indicated by the large percentage of polluttional organisms found on the Crow. Very few clean-water organisms were found in the bottom samples collected on the Crow River. The sample below Watertown contained 88 percent polluttional organisms.

The Rum River bottom samples indicated relatively moderate pollution of the river above Cambridge with about 50 percent of the organisms of the clean-water type. Below Cambridge the quality of water in Rum River deteriorates rapidly. At Station R-40, two miles below Cambridge, polluttional organisms made up 84 percent of the total. Three quarters of a mile further downstream, 98.7 percent of all forms were polluttional while only .15 percent were clean-water forms. Seventeen miles below Cambridge at Station R-20 the Rum River had materially recovered from its pollution load as indicated by 62 percent facultative forms, 31 percent clean-water forms, and only 6 percent of polluttional organisms.

At Station M-13, one-fourth mile below Rum River outlet, the water appeared relatively clean while near the north shore on the Anoka side large amounts of suspended matter and oil were noticed at the time when biological samples were being collected. Obviously, mixing of the Anoka sewage with the Mississippi River water was not taking place at this station. Bottom samples from the north side contained 80 percent polluttional and facultative organisms while bottom samples from the south side of the river had an extremely low count of both polluttional and facultative organisms. Five miles downstream, at Station M-8, the impounded area above Coon Rapids Dam acted as a settling basin for sludge from Anoka's sewers. The bottom fauna samples collected from the mud bottom of this impoundment revealed a very high percentage of polluttional organisms, especially sludge worms. At Station M-6 above St. Paul water intake and below Coon Rapids Dam, 97 percent of the bottom organisms were either clean-water forms or facultative.



BIOLOGICAL DATA—BOTTOM FAUNA
 RELATION OF POLLUTIONAL TO FACULTATIVE
 AND CLEAN WATER ORGANISMS

Adapted from map
 prepared by Minnesota
 State Department of Health

FIGURE 3

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 best available copy.

BENEFITS RESULTING FROM A PROGRAM OF POLLUTION PREVENTION AND ABATEMENT

The benefits arising from corrective and preventive measures are mostly those values related to public health. Inadequately treated domestic wastes create a menace to public health. The provision of adequate treatment of sewage is essential in reducing the threat of water-borne diseases and protecting the water for legitimate uses. The health hazard is most acute where heavily populated areas using surface water as a source for domestic water supply are located below sources of pollution. Effective pollution prevention measures would reduce the possibility of epidemics caused by disease organisms getting through the water treatment plants. They would also minimize the possibility of unpalatable water reaching the consumer.

Pollution prevention measures would improve water quality and provide a safer environment for swimming, boating, and fishing in many of the areas where pollution is now greater than that considered safe or desirable for those water uses.

The survey data collected from Station M-132 above Brainerd and Station M-130 below Brainerd show that an increase in coliform bacteria density from 25 above Brainerd to 13,800 below occurred before the sewage treatment plant was placed in operation. Operation of the plant reduced the coliform density below Brainerd to only 1,845.

Following the complete elimination of cannery waste from the South Fork of the Crow River at Watertown, there have been no reports of fish kills in the river below Watertown. No fish kills have been reported on Sucker Creek since the Cokato sewage treatment plant was placed in operation although periodic fish kills were regularly reported previous to the construction of this plant. The elimination of fish kills is a direct measure of the improvement of water quality resulting from the installation of pollution abatement facilities.

The benefits of pollution prevention and abatement to agriculture through improved livestock watering sources and improved pasturage may be realized when the value of the meat and dairy production to the basin is considered. Livestock can be watered by utilization of the ground water over most of the basin, but the advantages of surface water are apparent when the cost of obtaining ground water is compared with the utilization of readily available surface waters.

The expansion of the recreational activities in the basin is dependent on water that is satisfactory for bathing, boating, and fish and wildlife propagation. The impairment of this resource by pollution would curtail this important water use and reduce its economic value to the area.

THE POLLUTION CONTROL PROGRAM FOR THE BASIN

Present water uses and increased or additional uses required by the expanding population, recreational activities, and industry, together with adequate protection of water quality, largely determine the objectives of the pollution prevention program. In addition, nuisance conditions and the intangible aspects of moral obligation and aesthetic values exert a strong and positive influence for the justification of treatment facilities.

One of the more important objectives of the water pollution control program is protection of water quality in streams used as sources of public water supplies. The quality of raw water is an important factor in the design of water treatment facilities and their operation and maintenance. The factor of safety that can be incorporated in the best design is inversely proportional to the specific concentrations of bacteria and objectionable elements in the water used as source of supply. Therefore, it is desirable to keep these at a minimum within economic justification.

Another important objective of the pollution abatement program is the maintenance of water quality suitable for recreational use. Recreational waters should be free from floating solids, sludge banks, odors, and discoloration. Bathing waters should be kept free of contamination by sewage, especially that of recent origin.

The extent of the water pollution control activities in the basin is evidenced by the number of sewage and industrial waste treatment plants now in operation or in the planning and construction stage. There are 96 communities in the basin which have provided sewers for collecting and transporting the municipal waste out of the community. Table C, given below, is a summary of municipal treatment facilities data appearing in Appendix I.

TABLE C
EXISTING MUNICIPAL TREATMENT FACILITIES
January 1953

Degree of Treatment Provided	Number of Municipalities Served	Number of Treatment Plants	Population Served
Primary	27	27	27,026
Secondary	36	36	61,936
No Treatment	33	33	58,475
TOTAL	96	96	147,437

35-a



LOCATION MAP



NO TREATMENT NEEDED
 UNDETERMINED
 TREATMENT NEEDED
 A NEW PLANT
 B ENLARGEMENT OR ADDITIONS
 C REPLACE EXISTING PLANT
 S CONNECT TO CITY SEWERS
 E NEW SEWERS & NEW PLANT
 Note
 Numbers appearing by symbols
 indicate number of needs in
 the category designated



UPPER PORTION
 UPPER MISSISSIPPI RIVER BASIN
 MUNICIPAL
 WASTE TREATMENT NEEDS

U. S. DEPARTMENT OF
 HEALTH EDUCATION AND WELFARE
 Public Health Service
 DIVISION OF WATER POLLUTION CONTROL
 MAP NO. 5

Sixty-three of these communities also provide some form of treatment for their waste before it is discharged into the basin's waters. The treatment plants are divided into 27 primary treatment plants serving 27,026 people and 36 secondary treatment plants serving 61,936 people. The estimated population served by all of the communities with sewer systems is 147,437.

Twelve additional communities are actively engaged in the construction of or are planning to construct their first sewer systems. All of these communities will also provide treatment of their waste before discharge to the basin's waters. Table D indicates the adequacy of the capacity and operation of the existing plants. About 40 percent of the plants do not have adequate capacity or facilities to produce a satisfactory effluent under present conditions and water use. Many of these plants are 20 to 30 years old.

TABLE D
ADEQUACY OF EXISTING TREATMENT FACILITIES*
January 1953

Type of Plant	No. of Treatment Facilities	Adequacy with Relation to:					
		Capacity			Operation		
		Sat.	Unsat.	Undet'd	Sat.	Unsat.	Undet'd
Municipal	63	33	25	5	36	13	14
Industrial	71	55	15	1	55	12	4

*Summary of data appearing in Appendices I and II

Disposal of industrial waste has not been as pressing a problem as the disposal of municipal waste. Of the 269 industries in the basin which may be producing and discharging wastes, 71 are known to provide some degree of treatment and 7 are known to provide no treatment. The greatest producers of organic industrial pollution in the basin are the two major types of industries, paper and allied products, and food and kindred products. The paper plants all provide preliminary treatment for their wastes. Sixteen food and kindred products plants treat their wastes while 6 provide no treatment. Information is not available for the other 145 industries, but most of them are small establishments which are considered insignificant from a basin-wide pollution standpoint. Many of them may cause localized nuisance, but its severity has not been sufficient to cause it to be brought to the attention of the pollution control authorities.

There are 24 iron ore processing plants in the basin and 19 of these are known to provide some type of treatment for their wastes. The extent of mine drainage waste pollution in the basin is still partially undetermined. At present, 31 of 64 such sources are known to provide waste treatment.

Table B, appearing in the section "Pollution Discharged to Basin Waters," lists the types of industries in the basin and the treatment facilities provided for their wastes. Table D, above, shows the adequacy of the capacity and operation of these facilities.

Table E shows the construction of waste treatment facilities during the last five years.

TABLE E
PROGRESS IN CONSTRUCTION OF POLLUTION ABATEMENT FACILITIES
January 1953

Year	Sewage Treatment Plants Completed	Design Population
1948	2	10,750
1949	3	2,450
1950	1	2,750
1951	1	1,000
1952	7	4,150
TOTAL	14	21,100

Existing sewage and waste treatment facilities have provided the desired water quality protection in many areas of the basin, and many of the polluted sections of the streams have been eliminated. Areas still remain where pollution or nuisances are of such magnitude that corrective measures are considered necessary if the pollutional control program for the basin is to be fully met.

Sewage and waste treatment measures are designed to conform to water use requirements following an engineering evaluation of local conditions and problems. Some municipal treatment plants provide only for the removal of settleable material from the water. Where a higher degree of treatment is necessary, the removal of additional polluting material is accomplished by biological means. Industrial waste treatment processes vary widely, often within the same general type of industry. Changes in plant processes, by-products recovery, salvage, and improved housekeeping are often very effective measures of controlling industrial pollution. Control of industrial waste pollution may also present an entirely different problem from that of sewage disposal since the wastes may contain toxic or other objectionable substances not amenable to treatment by the processes commonly used for municipal sewage. However, the objective remains the same--protection of water quality by reduction of objectionable substances to within tolerance levels compatible with water uses.

Much has already been accomplished on the basin's pollution control program, but much is still needed before all sources of pollution or nuisances are brought under satisfactory control. Table F, prepared from detailed information given in Appendices I and II, lists the treatment facilities considered necessary to adequately protect the basin's waters.

TABLE F
POLLUTION ABATEMENT FACILITIES NEEDED
January 1953

Needs	Municipal		Industrial
	Number	Population Served by Sewers	Number
New Plant	32	57,675	6
Enlargement of, or Additions to Existing Plant	18	37,240	9
Replace Existing Plant	6	9,030	4
Connect to City Sewer	2	1,125	1
No Project Required	32	39,020	55
Undetermined	6	3,347	194

Note: In addition to the above, there are 12 unsewered communities with a total combined population of 6,590, which are actively planning the installation of sewers and treatment plants.

The progress being made and the status of action on these needed facilities is given in detail in Appendices I and II and condensed in Table G.

TABLE G
STATUS OF ACTION ON NEEDED POLLUTION ABATEMENT FACILITIES
January 1953

Status of Action	Number of Municipalities	Number of Industries
Inactive	15	5
Active Planning	20	5
Plans Approved	18	2
Under Construction	1	0
Undetermined	16	8

A P P E N D I C E S

APPENDIX I
BASIC DATA ON SOURCES OF MUNICIPAL POLLUTION
UPPER PORTION UPPER MISSISSIPPI RIVER DRAINAGE BASIN
January 1953

Municipality or Institution	1950 Popula- tion	Popula- tion Served by Sewers	Waste Treatment Provided	Adequacy of Treatment		Treatment Needs	Status of Municipal Action	Final Disposal To:
				Cap'y.	Opr.			
Aitkin	2,079	2,300	none	--	--	new plant	plans appr.	Mississippi R.
Albany	1,196	880	primary	unsat.	unsat.	replace pt.	plans appr.	Two Rivers
Alexandria	6,319	4,500	secondary	unsat.	sat.	addition	plans appr.	Lake Winona
Anondale	899	670	primary	unsat.	sat.	addition	undet.	Pleasant Lake
Anoka	7,396	5,800	primary	unsat.	undet.	replace pt.	act planning	Mississippi R.
Anoka St. Hospital	--	1,300	primary	unsat.	sat.	replace pt.	inactive	Rum River
Anoka Airport	--	undet.	primary	unsat.	undet.	replace pt.	plans appr.	Mississippi R.
Atwater	880	730	none	--	--	new plant	inactive	Crow R.
Bemidji	10,001	7,200	secondary	unsat.	sat.	enlargement	act. planning	Mississippi R.
Bertha	577	540	secondary	sat.	unsat.	none	--	Creek-Crow Wing R.
Bock	96	100	secondary	sat.	unsat.	none	--	Bogus Cr. - Rum R.
Bovey	1,320	1,200	primary	undet.	unsat.	undet.	--	Trout Lake
Braham	697	undet.	secondary	sat.	unsat.	none	--	Ditch-Rum R.
Brainerd	12,637	11,000	secondary	sat.	unsat.	none	--	Mississippi R.
Brooton	669	none	--	--	--	sewers &	plans appr.	--
Browntn	696	650	none	--	--	new plant	undet.	Lake Addie
Buffalo	1,914	1,500	secondary	sat.	undet.	new plant	--	Buffalo Lake
Buffalo Lake	724	570	none	--	--	new plant	undet.	Buffalo Lake
Calumet	854	850	primary	sat.	unsat.	none	--	Ditch-Rum R.
Cambridge	2,978	1,400	none	--	--	new plant	plans appr.	Rum R.
Cambridge St. Sch.	--	1,200	none	--	--	new plant	act. planning	Rum R.
Cass Lake	1,936	1,700	none	--	--	new plant	plans appr.	Cass Lake
Clarissa	650	470	secondary	sat.	sat.	none	--	Eagle Cr.-Long Prairie R.
Clear Lake	297	none	--	--	---	sewers &	act. planning	--
						new plant	--	
Cokato	1,403	1,000	secondary	sat.	sat.	none	--	Sucker Cr.-N.F. Crow R.

APPENDIX I (Cont'd.)

Municipality or Institution	1950 Popula- tion	Popula- tion Served by Sewers	Waste Treatment Provided	Adequacy of Treatment Provided		Treatment Needs	Status of Municipal Action	Final Disposal To:
				Cap'y.	Opr.			
Cold Springs	1,488	1,275	none	--	--	new plant	inactive	Sauk R.
Coleraine	1,321	1,200	primary	undet.	undët.	undet.	--	Trout Lake
Cooley	113	120	none	--	--	new plant	inactive	--
Cromwell	197	none	--	--	--	sewers & new plant	under const.	--
Crosby	2,777	2,600	primary	unsat.	undet.	new plant	inactive	Serpent Cr.
Cuyuna	112	100	none	--	--	addition	inactive	Creek-Mississippi R.
Deer River	1,033	500	none	--	--	new plant	plans appr.	Deer R.
Deer Wood	572	500	primary	undet.	undet.	new plant	--	Cranberry Lake
Deer Wood Sanatorium	--	36	primary	undet.	undet.	undet.	--	Clear Brook
Delano	1,386	none	--	--	--	sewers & new plant	act. planning	--
Eagle Bend	691	none	--	--	--	sewers & new plant	act. planning	--
Elk River	1,399	1,100	none	--	--	new plant	plans appr.	Mississippi R.
Flensburg	281	100	primary	sat.	sat.	none	--	Slough-Pine Cr.
Foley	1,080	900	secondary	sat.	sat.	none	--	Stoney Brook-Elk R.
Freeport	558	490	primary	unsat.	undët.	replace pt.	undet.	Gatchell Cr.-Sauk R.
Glencoe	2,801	2,100	secondary	unsat.	unsat.	enlargement	act. planning	Buffalo Cr.
Grand Rapids	6,019	4,400	none	--	--	new plant	plans appr.	Mississippi R.
Greenwald	207	none	--	--	--	sewers & new plant	plans appr.	--
Grovo City	401	400	primary	unsat.	sat.	additions	undet.	N. Fork Crow R.
Hackensack	272	none	--	--	--	sewers & new plant	act. planning	--
Hector	1,196	960	none	--	--	new plant	undet.	Buffalo Cr.
Henning	1,004	850	secondary	sat.	sat.	none	--	Willow R.
Holdingford	458	460	none	--	--	new plant	plans appr.	Two Rivers
Howard Lake	1,931	550	secondary	sat.	undet.	none	--	N. Fork Crow R.
Hutchinson	4,690	3,500	secondary	unsat.	sat.	enlargement	inactive	Crow R.

APPENDIX I (Cont'd.)

Municipality or Institution	1950 Popula- tion	Popula- tion Served by Sewers	Waste Treatment Provide	Adequacy of Treatment Provided	Cap'y.	Opr.	Treatment Needs	Status of Municipal Action	Final Disposal To:
Ironton	828	750	primary	sat.	sat.	sat.	none	--	Creek-Blackhoff Lake
Isle	674	560	primary	unsat.	undet.	undet.	replace pt.	act. planning	Knife R.-Rum R.
Kandiychi	293	240	secondary	sat.	undet.	undet.	none	--	Crow R.
Keewatin	1,807	1,900	secondary	sat.	sat.	sat.	none	--	O'Brien Cr.-Swan R.
Lake Henry	97	60	secondary	sat.	sat.	sat.	none	--	--
Lester Prairie	663	none	--	--	--	--	sewers & new plant	act. planning	--
Litchfield	4,608	3,900	secondary	unsat.	sat.	sat.	enlargement	inactive	Jewett Cr.-Crow R.
Little Falls	6,717	5,800	none	--	--	--	new plant	inactive	Mississippi R.
Camp Ripley	undet.	undet.	secondary	sat.	sat.	sat.	none	--	Mississippi R.
Long Prairie	2,443	2,000	secondary	sat.	sat.	sat.	none	--	Long Prairie R.
Manganese	41	60	none	--	--	--	new plant	inactive	Mississippi R.
Maple Lake	780	570	primary	unsat.	unsat.	unsat.	enlargement	act. planning	Ramsay Lake-Crow R.
Maple Plain	479	320	secondary	sat.	sat.	sat.	none	--	Painter Cr.
Marblo	867	720	primary	sat.	sat.	sat.	none	--	L. Minnetonka
Melrose	2,106	1,800	none	--	--	--	new plant	act. planning	Mud Cr.-Mud L.-Miss. R.
Monahga	339	undet.	secondary	sat.	sat.	sat.	none	act. planning	Sauk R.
Milaca	1,917	1,500	none	--	--	--	new plant	plans appr.	Blueberry R.-Miss. R.
Milona	150	undet.	secondary	sat.	sat.	sat.	none	--	Rum R.
Monticello	1,231	1,000	none	--	--	--	new plant	plans appr.	Mississippi R.
Montrose	300	240	none	--	--	--	new plant	undet.	Ditch-Crow R.
Nashwauk	4,029	2,000	none	--	--	--	new plant	inactive	Ditch-Swan Lake
New London	726	none	--	--	--	--	sewers & new plant	act. planning	--
Onamia	704	undet.	secondary	sat.	sat.	sat.	none	--	Rum R.
Osakis	1,488	1,300	secondary	unsat.	sat.	sat.	enlargement	undet.	Osakis Lake-Sauk R.
Perkers Prairie	900	700	secondary	sat.	undet.	undet.	none	--	Lake Adley-Miss. R.
Park Rapids	3,027	2,400	primary	sat.	sat.	sat.	none	--	Fish Hook R.-Miss. R.
Paynesville	1,503	1,200	primary	unsat.	unsat.	unsat.	additions	inactive	Crow R.
Pierz	856	none	--	--	--	--	sewers & new plant	act. planning	--

APPENDIX I (Cont'd.)

Municipality or Institution	1950 Popula- tion	Popula- tion Served by Sewers	Waste Treatment Provided	Adequacy of Treatment Provided		Treatment Needs	Status of Municipal Action	Final Disposal To:
				Cap'y.	Op'r.			
Pine River	835	520	none	--	--	new plant	plans appr.	Norway R.
Princeton	2,108	1,600	primary	unsat.	sat.	addition	undct.	Rum R.
Romer	412	150	none	--	--	new plant	act. planning	Willow R.
Richmond	700	570	none	--	--	new plant	undct.	Sauk R.
Riverton	148	130	primary	unsat.	undct.	addition	inactive	Serpent R.
Jt. Cloud	28,410	21,000	none	--	--	new plant	plans appr.	Mississippi R.
St. Cloud St. Reform.	--	800	none	--	--	to municipal sewer	undct.	Mississippi R.
St. Joseph	1,246	900	none	--	--	new plant	plans appr.	Watab R.
St. Michael	487	350	none	--	--	new plant	plans appr.	Creek-Crow R.
Sartell	662	470	none	--	--	new plant	act. planning	Watab R.
Sauk Center	3,140	3,000	secondary	sat.	sat.	none	--	Sauk R.
St. Sch. for Girls	--	325	primary	sat.	unsat.	to municipal sewer	undct.	Sauk R.
Sauk Rapids	3,410	2,700	none	--	--	new plant	undct.	Mississippi R.
Sebek	802	500	secondary	sat.	sat.	none	--	Red Eye R.-Miss. R.
Silver Lake	603	300	secondary	sat.	sat.	none	--	Silver Lake-Crow R.
Spring Hill	91	none	--	--	--	sewers & new plant	act. planning	--
Staples	2,782	2,600	secondary	unsat.	sat.	enlargement	undct.	Hayden Cr.-Crow Wing R.
Stewart	695	570	none	--	--	new plant	undct.	Buffalo Cr.
Taconite	322	375	primary	unsat.	unsat.	undct.	--	Ditch-Swan R.
Trommald	117	150	none	--	--	new plant	inactive	Lake Mahanoma
Verndale	576	none	--	--	--	sewers & new plant	act. planning	--
Wadena	3,958	2,600	secondary	unsat.	sat.	enlargement	act. planning	Union Cr.-Red Eye R.
Fair Oaks Lodge San.	--	36	secondary	undct.	undct.	undct.	--	--
Waite Park	1,639	1,250	primary	unsat.	sat.	addition	undct.	Sauk R.
Walker	1,192	840	secondary	sat.	sat.	none	--	Leech Lake-Miss. R.
Ah-Gwah-Ching St. T.B. San.	--	330	secondary	sat.	sat.	none	--	Leech Lake-Miss. R.

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APPENDIX 1 (Cont'd.)

Municipality or Institution	1950 Popula- tion	Popula- tion Served by Sewers	Waste Treatment Provided	Adequacy of Treatment Provided		Treatment Needs	Status of Municipal	Final Disposal To:
				Cap'y.	Opr.			
Watertown	837	660	primary	unsat.	sat.	addition	inactive	Crow R.
Watkins	659	undet.	secondary	sat.	sat.	incro	--	Creek - Miss. R.
Waverly	493	460	primary	unsat.	unsat.	addition	act. planning	Lake Waverly
Willmar	9,410	6,800	secondary	sat.	sat.	none	--	S. Fork Crow R.

APPENDIX II
BASIC DATA ON SOURCES OF INDUSTRIAL WASTE POLLUTION
UPPER PORTION OF UPPER MISSISSIPPI RIVER DRAINAGE BASIN
JANUARY 1953

Municipality Industry	Type of Industry	Type of Waste Produced	Treatment or Other Pollu- tion Control Measures			Pollution Abatement Needs	Current Status of Industrial Action
			Degree	Adequacy Cap'y.	Opr.		
Aldrich	cheese	organic					
Aldrich Milk Products Co.							
Almora	cheese	organic	primary	unsat.	unsat.	replace pt.	inactive
Almora Cheese Factory							
Arbo Twp. Itasca Co.	mining	inorganic	primary	sat.	sat.	none	
Buckeye Mine	mining	inorganic					
Jennison Mine	mining	inorganic	primary	sat.	sat.	none	
West Hill Mine							
Bovey	mining	inorganic					
Danube-Orwell Mine	ore process	inorganic					
Pickens-Mather Co. Danube Pt.	mining	inorganic					
Walker Mine							
Brainerd	fermentation	organic	minor	sat.	undet.	none	
Fitzger Brewing Co.	paper	org. & inorg.					
Northwest Paper Co.	milk plant	organic					
Inter Lakes Dairy							
Browerville	creamery	organic	secondary	unsat.	unsat.	enlargement	plans approved
Farmers Coop. Cry. Assn.	condensery	organic	secondary	unsat.	unsat.	enlargement	plans approved
Todd County Dairy Coop.							
Callumet	ore process	inorganic	primary	sat.	sat.	none	
Johns & Laughlin Hill Annex Pt.							
Clough Twp. Crow Wing Co.	mining	inorganic					
Gorman Mine							
Cokata	canning	organic	secondary	sat.	sat.	none	
Green Giant Canning Co.	canning	organic	secondary	sat.	sat.	none	
Northland Canning Co.							
Coleraine	mining	inorganic					
Canisteo Mine	ore process	inorganic	primary	sat.	sat.	none	
Cleveland-Cliffs Canisteo Pt.	ore process	inorganic					
Hanna Ore Mining Co. Buckeye Pt.	mining	inorganic					
King Mine	mining	inorganic					
Morrison Mine	mining	inorganic					

APPENDIX II (Cont'd.)

APPENDIX II (Cont'd.)			Treatment or Other Pollut-		Pollution Abatement Needs	Current Status of Industrial Action
Type of Industry	Type of Waste Produced	Degree	Control Measures	Adequacy		
			Cap'y.	Opr.		
Municipality						
Industry						
Coleraine (Cont'd.)	Pt. ore process	inorganic	primary	sat.	none	
Oliver Iron Mining	Trout Lake	inorganic	primary	sat.	none	
Plummer Mine	mining			unsat.	replace pt.	inactive
Cooley	ore process	inorganic	primary	sat.	none	
Butler Bros. Harrison Pt.	ore process	inorganic	primary	sat.	none	
Butler Bros. Patrick A Pt.	ore process	inorganic	primary	sat.	none	
Butler Bros. Patrick B Pt.	ore process	inorganic	primary	sat.	none	
Butler Bros. Harrison Mine	mining	inorganic	primary	sat.	none	
Harrison Mine	mining	inorganic	primary	sat.	none	
Kevin Mine	mining	inorganic	primary	sat.	none	
Olson Mine	mining	inorganic	primary	sat.	none	
Patrick Ann Mine	mining	inorganic	primary	sat.	none	
Patrick Annex Mine	mining	inorganic	primary	sat.	none	
Crosby	mining	inorganic	primary	sat.	none	
Armour No. 2 Mine	ore process	inorganic	primary	sat.	none	
Hanna Portsmouth Pt.	mining	inorganic	primary	sat.	none	
Manuel Mine	mining	inorganic	primary	sat.	none	
Portsmouth Mine	ore process	inorganic	primary	sat.	none	
Zantelli Bros. Manuel Pt.						
Dalbo	cheese	organic	none			
Dalbo Creamery Co.	canning	organic				
Deerwood	dry milk	organic				
Hunts Cannery	cheese	organic				
Eden Valley	pharmaceutical	organic				
Eden Valley Creamery	chemical	organic				
Enfield	canning	organic				
Enfield Cheese Co.	food	organic				
Minnichlor Inc.						
Fridley						
National Pole & Treating Plant						
Glencoe						
Green Giant Co.						
Vegetable Oil Plant						

(irrigation no waste
reaches watercourse)

APPENDIX II (Cont'd.)

Municipality Industry	Type of Industry	Type of Waste Produced	Treatment or Other Pollution Control Measures	Degree	Adequacy		Pollution Abatement Needs	Current Status of Industrial Action
					Cap'y.	Opr.		
Grand Rapids								
Blandin Paper Co.	paper	org. & inorg.		minor	unsat.	undet.	additions	undet.
Arrowhead Canning Co.	canning	organic		none	--	--	new plant	inactive
Grand Rapids Twp. Itasca Co.								
Jessie Mine	mining	inorganic		primary	sat.	sat.	none	
Hasty								
Modern Coop. Cheese Co.	cheese	organic						
Holdingford								
Holdingford Farmers Creamery	creamery	organic		primary	unsat.	unsat.	replace pt.	
Opole Cheese Factory	cheese	organic		primary				
Irondale Twp. Crow Wing Co.								
Joan #1 Mine	mining	inorganic		none	--	--	new plant	
Louise Mine	mining	inorganic						
Mahonmen Mine	mining	inorganic		primary	sat.	sat.	none	
Mallen Mine	mining	inorganic		primary				
Mangan #1 Mine	mining	inorganic		primary	sat.	sat.	none	
Section 6 Mine	mining	inorganic		primary	sat.	sat.	none	
Virginia Mine	mining	inorganic		primary	sat.	sat.	none	
Ironton								
Alstead Mine	mining	inorganic		primary	sat.	sat.	none	
Armour #1	mining	inorganic		primary	sat.	sat.	none	
Dates Mining Co. Pennington Pt.	ore process	inorganic		primary	sat.	sat.	none	
Feigh Mine	mining	inorganic		primary	sat.	sat.	none	
Huntington Mine	mining	inorganic		primary	sat.	sat.	none	
Pennington Mine	mining	inorganic		primary	sat.	sat.	none	
Isanti								
Isanti Farmers Creamery Co.	dry milk	organic						
Keewatin								
Bennett Mine	mining	inorganic		primary	sat.	sat.	none	
Cleveland-Cliffs	ore process	inorganic		primary	sat.	sat.	none	
Hanna Coal & Ore Corp. Perry Pt.	ore process	inorganic		primary	sat.	sat.	enlargement	act. planning
Hanna Iron Ore Co. Section 18 Pt.	ore process	inorganic		primary	sat.	sat.	none	
Hanna Ore Mining Mesabi Ch. Pt.	ore process	inorganic		primary	sat.	sat.	none	
Mississippi #1 Mine	mining	inorganic		primary	sat.	sat.	none	
Mississippi #3 Mine	mining	inorganic		primary	sat.	sat.	none	

APPENDIX II (Cont'd.)

Municipality Industry	Type of Industry	Type of Waste Produced	Treatment or Other Poll- tion Control Measures			Pollution Abatement Needs	Current Status of Industrial Action
			Degree	Adequacy Cap'y.	Opr.		
Keewatin (Cont'd.)							
Pickland, Mather Bennett Pt.	ore process	inorganic	primary	sat.	sat.	none	
Republic Steel, St. Paul Pt.	ore process	inorganic	primary	sat.	sat.	none	
Sargent Mine	mining	inorganic					
St. Paul Mine	mining	inorganic					
St. Paul Day Mine	mining	inorganic					
Kimball							
Kimball Creamery Co.	dry milk	organic					
Lawler	cheese	organic	primary	sat.	sat.	none	
Lawler Coop. Cry. Assn.	cheese	organic					
Lester Prairie	cheese	organic					
Milk Foods Specialties Inc.							
Little Falls	paper	org. & inorg.	minor	unsat.	undet.	undet.	
St. Regis Paper Co.							
Long Prairie (outside city)	rendering	organic	primary	sat.	sat.	none	
Long Prairie Rendering Co.	meat	organic	none	--	--	new plant	
Northwest Packing Co.							
Marble							
Delaware #2 Mine	mining	inorganic					
Gross-Marble Mine	mining	inorganic					
Hill Annex Mine	mining	inorganic	primary	sat.	sat.	none	
Hill-Tromball Mine	mining	inorganic	primary	sat.	sat.	none	
Mesabi-Cliffs Hill-Tromball Pt.	ore process	inorganic	primary	unsat.	unsat.	replace pt.	inactive
Oliver Iron Mining Co. Marble Pt.	ore process	inorganic					
Mayer							
Mayer Coop. Cry. Assn.	dry milk	organic					
Nashwauc							
Cleveland Cliffs Hawkins Pt.	ore process	inorganic	primary	unsat.	unsat.	replace pt.	act. planning
Halobé Mine	mining	inorganic	primary	sat.	sat.	none	
Hawkins Mine	mining	inorganic	primary	sat.	sat.	none	
North Harrison Mine	mining	inorganic	primary	sat.	sat.	none	
Pacific Isle Mining York Pt.	ore process	inorganic					
Perry Mine	mining	inorganic	primary	sat.	sat.	none	

APPENDIX II (Cont'd.)

Municipality Industry	Type of Industry	Type of Waste Produced	Treatment or Other Pollu- tion Control Measures			Pollution Abatement Needs	Current Status of Industrial Action
			Degree	Adoquacy Cap'y.	Opr.		
Nashauk (Cont'd.)							
Quinn Mine	mining	inorganic					
York Mine	mining	inorganic					
Nashauk Twp.							
Brae Mine	mining	inorganic	primary	sat.	sat.	none	
Mesabi Chief Mine	mining	inorganic	primary	sat.	sat.	none	
Stein Mine	mining	inorganic					
Wyman Mine	mining	inorganic					
Oaklawn Twp. Crow Wing Co.							
Syracuse Mine	mining	inorganic					
Parkers Prairie							
Parkers Prairie Coop. Cry. Assn.	dry milk	organic	secondary	sat.	sat.	none	
Princeton (outside city)							
Princeton Rendering Co.	rendering	organic	primary	unsat.	sat.	enlargement	act. planning
Rabbit Lake Twp. Crow Wing Co.							
Rabbit Lake Mine	mining	inorganic	primary	sat.	sat.	none	
Riverton							
Manganese Chemical Corp.	chemical	inorganic	primary	sat.	sat.	none	
Sagamore mine	mining	inorganic					
Rockford							
Twin City Milk Prod. Assn.	dry milk	organic					
St. Cloud							
Landy Packing Co.	meat	organic	none	--	--	connect to city sewer	act. planning
St. Cloud Rendering Co.							
Sartell							
St. Regis Paper Co.	rendering	organic	secondary	sat.	sat.	none	
Stuntz Twp. St. Louis Co.							
Agnew Mine	paper	org. & inorg.	minor	unsat.	unsat.	additions	
Carlz #1 Mine	mining	inorganic	primary	sat.	sat.	none	
Morton Mine	mining	inorganic	primary	sat.	sat.	none	
Section 18 Mine	mining	inorganic	primary	sat.	sat.	none	
South Agnew Mine	mining	inorganic	primary	sat.	sat.	none	

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APPENDIX II (Cont'd.)

Municipality Industry	Type of Industry	Type of Waste Produced	Treatment or Other Pollu- tion Control Measures			Current Status of Industrial
			Degree	Adequacy Cap'y.	Abatement Opr. Needs	
Stuntz Twp. St. Louis Co. (Cont'd.)						
South Stephenson Mine	mining	inorganic				
Stephenson Mine	mining	inorganic				
Taconite						
Arcturus Mine	mining	inorganic				
Holman-Cliffs Mine	mining	inorganic				
Mecabi-Cliffs Holman Cliff Pt.	ore process	inorganic	primary	unsat.	unsat.additions	inactive
Trommald			primary	sat.	sat. none	
Hanna Co. Maroco Pt.	ore process	inorganic	primary	sat.	sat. none	
Maroco Mine	mining	inorganic	primary	unsat.	unsat.enlargement	
Zontelli Bros. Virginia Pt.	ore process	inorganic	primary	sat.	sat. none	
Watertown						
Green Giant Co.	canning	organic	complete	sat.	sat. none	(irrigation no waste reaches watercourse)
Winsted						
Green Giant Co.	canning	organic	minor	unsat.	unsat.additions	act. planning
Pure Milk Prod. Inc.	cheese	organic	none	--	-- new plant	
Wright						
Twin Ports Coop. Dairy Assn.	cheese	organic				

APPENDIX II SUPPLEMENT

In addition to the industries listed in the basic data table, there are several small industries located in communities without sewers and in unsewered areas of other towns. These industries produce organic wastes and, as no municipal sewers are available to them, they must discharge wastes to the basin's surface waters. A list of these industries is given below:

Community	Industry	Type of Industry
Akeley	Akeley Cry. Co.	creamery
	Grant S. Voshell	food locker
	Wefelmeyer Pickle Corp.	canning
Albany	Holding Farmers Cry.	creamery
	St. Anthony Coop. Cry. Assn.	creamery
Avon	Avon Farmers Cry.	creamery
Backus	Backus Cry. Co.	creamery
	Arthur Bugener	food locker
Becker	Becker Cry.	creamery
Belgrade	Belgrade Flour Mill Co.	food
	Farmers Coop. Cry. Assn.	creamery
	J. L. Gordhamer	food locker
Bethel	Bethel Cry.	creamery
Biscay	Biscay Coop. Cry. Assn.	creamery
Bluffton	Bluffton Coop. Cry. Assn.	creamery
Bowlus	Elm Dale Cry. Assn.	creamery & locker
Braham	Day Coop. Cry.	creamery
Brooton	Brooton Coop. Cry. Assn.	creamery
	Grove Lake Cry. Corp.	food locker
	Alton Jensen	food locker
Buckman	Buckman Farmers Coop. Cry.	creamery
Carlos	Belle River Cry. Co.	creamery
	Carlos Coop. Cry. Co.	creamery
	Arthur S. Martin	food locker
Cedar Mills	Cedar Mills Coop. Cry. Assn.	creamery
Centerville	Thomas G. Mitchell	food locker
Clear Lake	John L. McDonald	food locker
Clearwater	Clearwater Coop. Locker Co.	food locker
	Clearwater Coop. Cry. Assn.	creamery
Corvuso	Corvuso Cry. Co.	creamery & locker
Cosmos	Cosmos Coop. Cry. Assn.	creamery & locker
Cushing	Cushing Cry. Co.	creamery
Dalbo	R. C. Wendberg	food locker
Darwin	Darwin Coop. Cry. Assn.	creamery & locker
Dassel	Dassel Coop. Cry. Assn.	creamery
	Dassel Food Lockers	food locker
	Kingston Coop. Cry. Assn.	creamery
Day	Pick Food Processing Assn.	food locker
Deer Creek	Farmers Coop. Cry. Assn.	creamery & locker
Delano	Delano Coop. Cry. Assn.	creamery & milk plant
	Rieder Bros.	food locker
Eagle Bend	Arthur C. Bill	food locker
	Eagle Bend Coop. Cry.	creamery

APPENDIX II SUPPLEMENT (Cont'd.)

Community	Industry	Type of Industry
Edon Valley	Art Weis	food locker
Elrosa	Elrosa Coop. Cry. Co.	creamery
	Edwin J. Kochmann	food locker
Foley	Ramey Farmers Coop. Cry.	creamery
Freeport	St. Francis Cry.	creamery
Gilman	Gilman Coop. Cry.	creamery
Greenwald	Greenwald Coop. Cry. Assn.	creamery
	C. A. Uphoff	food locker
Grey Eagle	Grey Eagle Coop. Cry. Assn.	creamery
	Theo. H. Schneklloth	food locker
Grove City	Dannialson Cry. Co.	creamery
	Manannah Cry.	creamery
Hackonsack	Doed Schroeder	food locker
Hamburg	Hamburg Coop. Locker Assn.	food locker
	Hamburg Dairy Assn.	creamery
Hewitt	Hewitt Coop. Cry.	creamery
Hillman	Clover Belt Coop. Cry. Assn.	creamery
	John Gotvold	food locker
	Hillman Coop. Cry.	creamery
Hugo	Andre & Henry J. Marier	food locker
Isanti	Isanti Coop. Cry. Assn.	creamery
	Isanti County Coop. Assn.	food locker
	Theo. A. Johnson	food locker
Kimball	C. P. Knaus	food locker
Kingston	Kingston Coop. Dairy Assn.	food locker
Lake Lillian	Lillian Cry. Co.	creamery & locker
Lastrup	Lastrup Coop. Cry.	creamery & locker
Leader	Farmers Coop. Cry. Assn.	creamery
	Staples Locker System	food locker
Lester Prairie	McLeod-Wright Cry. Co.	creamery
	Albert Thiel	food locker
Litchfield	Forest City Coop. Cry.	food locker
Longville	Kenneth E. Strait	food locker
Loretto	Eugene C. Koch	food locker
McGregor	John H. Holms	food locker
	McGregor Cry. Co.	creamery & milk plant
Meire Grove	C. A. Uphoff	food locker
Melrose	Meire Grove Coop. Dairies	creamery
	Spring Hill Cry. Co.	creamery
Motley	Motley Cry. Co.	creamery
Nelson	Nelson Cry. Assn.	creamery
Nevis	Nevis Cry. Co.	creamery & milk plant
New Germany	Borchert Bros. Dairy	milk plant
	Alois P. Efferts	food locker
New London	New London Cry. Assn.	creamery
	Rose Market	food locker
New Munic	New Munic Cold Storage	food locker
	New Munic Coop. Cry. Assn.	creamery
Nimrod	Nimrod Coop. Cry. Assn.	creamery
Osseo	Andrew John Wisby	food locker
Padua	C. A. Uphoff	food locker

APPENDIX II SUPPLEMENT (Cont'd.)

Community	Industry	Type of Industry
Palisade	Palisade Coop. Cry. Assn.	creamery
	C. A. Uphoff	food locker
Pease	Farmers Coop. Cry.	creamery
Pequot Lakes	Coop. Cry. Assn.	creamery
	H. N. Everhart	food locker
	North Pine Dairy	milk plant
Pierz	Myers Dairy	milk plant
	Pierz Coop. Cry. Assn.	creamery
	J. H. Schaeffer	food locker
Pillager	Brainerd Locker Co.	food locker
	Farmers Coop. Cry. Co.	creamery
Plato	Leonard & Davis Litzav	food locker
	Plato Dairy Assn.	creamery
Ramey	Lynn Crowe	food locker
Randall	Don McGee	food locker
	Randall Coop. Cry. Assn.	creamery
Rice	Rice Farmers Coop. Cry.	creamery
	William Thiessen	food locker
Rockford	Herman F. Kothrade	food locker
Rockville	Rockville Coop. Cry. Assn.	creamery
Rogers	Elmer Scharber	food locker
	Scherber Store Co.	food locker
Roscoe	Roscoe Cry. Co.	creamery
	Sauk Valley Cry. Co.	creamery
Rosendale	Danielson Cry. Co.	food locker
Royalton	Little Rock Coop. Cry. Co.	creamery
	Royalton Coop. Cry. Co.	creamery
	Wendel B. Thiessen	food locker
St. Martin	Cold Storage Locker Co.	food locker
Santiago	Santiago Coop. Cry.	creamery
Sedan	Sedan Cry. Co.	creamery
Shozvin	Farmers Coop. Cry. Assn.	creamery & locker
Silver Creek	Silver Creek Coop. Cry.	creamery & locker
Sobieski	Sobieski Farmers Cry.	food locker
Southhaven	J. G. Lies & Sons	food locker
Spicer	Great Lake Locker Plant	food locker
Spring Hill	Melrose Locker Plant	food locker
Swanville	Swanville Coop. Cry. Assn.	creamery & locker
Upsala	Ewalp Sadlowsky	food locker
	Upsala Coop. Cry.	creamery
Verndale	E. E. Davis	food locker
	Verndale Cry. Assn.	creamery
Watkins	P. H. Weber	food locker
West Union	Farmers Coop. Cry. Assn.	creamery
Winsted	City Meat Market	food locker
	Winsted Farmers Coop. Cry.	creamery

APPENDIX III
MUNICIPAL WATER SUPPLIES

Municipality	1950 Popula- tion	Popula- tion Served	Source of Supply	Average Plant Output Gallons/day
Aitkin	2,079	1,500	wells	50,000
Akeley	525	500	Eleventh Lake	50,000
Albany	1,196	600	wells	60,000
Alexandria	6,319	5,100	wells	200,000
Annandale	899	270	well	80,000
Anoka	7,396	5,250	well	260,000
Atwater	880	540	well	25,000
Belgrade	659	90	well	14,000
Bemidji	10,001	2,970	wells	300,000
Bertha	577	380	well	15,000
Bock	96			
Bovey	1,320	940	see Coleraine	--
Braham	697	350	well	10,000
Brainerd	12,637	12,070	wells	700,000
Brooton	669	280	well	60,000
Browerville	735	280	wells	30,000
Brownton	696	840	well	84,000
Buckman	173	20	well	2,000
Buffalo	1,914	1,660	well	90,000
Buffalo Lake	724	350	well	20,000
Calumet	854	770	wells	30,000
Cambridge	2,978	1,350	wells	120,000
Cass Lake	297	560	wells	38,000
Clarissa	650			
Clear Lake	297			
Cokato	1,403	1,120	wells	112,000
Cold Spring	1,488	700	well	22,000
Coleraine	1,321	1,200	wells	120,000
Cooley	113	120	well	12,000
Cosmos	382	200	well	9,000
Cromwell	197			
Crosby	2,777	2,630	wells	150,000
Cuyuna	112	190	well	12,000
Dassel	962	700	well	50,000
Deer River	1,033	440	well	50,000
Deerwood	572	260	well	20,000
Delano	1,386	1,090	well	100,000
Eagle Bend	691			
Eden Valley	792	270	well	4,000
Elk River	1,399	780	wells	90,000
Flensburg	281			
Foley	1,080	380	well	40,000
Freeport	558	400	well	25,000
Glencoe	2,801	1,600	well	45,000
Grand Rapids	6,091	4,875	well	175,000
Greenwald	207			
Grove City	481	360	well	16,000

APPENDIX III (Cont'd.)

Municipality	1950 Popula- tion	Popula- tion Served	Source of Supply	Average Plant Output Gallons/day
Hackensack	272			
Hamburg	184	260	well	4,000
Hector	1,196	880	well	32,000
Henning	1,004	420	well	10,000
Hill City	501	250	wells	50,000
Holdingford	458	210	wells	18,000
Howard Lake	1,931	850	well	9,000
Hutchinson	4,690	3,000	well	300,000
Ironton	828	700	well	70,000
Isle	674	170	well	17,000
Kandiyohi	293	190	well	19,000
Keewatin	1,807	1,570	wells	73,000
Kimball	479	310	well	15,000
Lake Henry	97			
Lester Prairie	663	280	well	30,000
Litchfield	4,608	2,100	wells	175,000
Little Falls	6,717	6,050	wells	500,000
Long Prairie	2,443	2,300	wells	140,000
Loretto	179	140	well	8,000
Manganese	41			
Maple Lake	780	530	wells	25,000
Maple Plain	479	280	wells	15,000
Marble	867	260	well	30,000
Melrose	2,106	2,015	wells	150,000
Menahga	839			
Milaca	1,917	1,140	wells	114,000
Miltona	150			
Monticello	1,231	700	well	70,000
Montrose	300	275	well	30,000
Nashwauk	2,029	2,200	Hawkins Mine	172,000
New London	726			
New Munic	277	180	well	4,000
New York Mills	977	450	well	45,000
Onamia	704	320	wells	12,000
Osakis	1,488	790	wells	79,000
Osseo	1,167	390	wells	100,000
Parkers Prairie	900	470	wells	30,000
Park Rapids	3,027	2,600	wells	200,000
Paynesville	1,503	930	well	50,000
Pierz	856	560	wells	56,000
Pine River	835			
Princeton	2,108	1,500	well	150,000
Romer	412	180	wells	18,000
Richmond	700	390	well	39,000
Riverton	148	110	well	11,000
Royalton	500	210	well	50,000
St. Anthony	66			
St. Cloud	28,410	24,170	Mississippi River	1,500,000
St. Joseph	1,246	1,055	well	100,000
St. Michael	487	140	wells	12,000

APPENDIX III (Cont'd.)

Municipality	1950 Popula- tion	Popula- tion Served	Source of Supply	Average Plant Output Gallons/day
Sartell	662			
Sauk Center	3,140	2,200	wells	205,000
Sauk Rapids	3,410	1,610	well	100,000
Seboka	802	500	well	50,000
Silver Lake	603	350	well	19,000
Spicer	566	110	well	13,000
Spring Hill	91			
Staples	2,782	2,950	wells	100,000
Stewart	695	550	well	55,000
Swanville	373	210	well	21,000
Taconite	322	260	well	26,000
Trommald	117			
Upsala	366	150	well	1,000
Verndale	576	400	well	30,000
Wadena	3,958	2,380	wells	100,000
Waite Park	1,639	740	well	40,000
Walker	1,192	930	well	75,000
Watertown	837	700	wells	24,000
Watkins	659	480	wells	15,000
Waverly	493	450	wells	50,000
Willmar	9,410	5,600	well	448,000
Winsted	941	460	well	15,000
Total wells	170,480	110,720		7,579,000
Total surface	30,849	25,820		1,630,000

APPENDIX IV
RIVER POLLUTION STUDY SAMPLING STATIONS
MISSISSIPPI RIVER SURVEY

Sample stations on the main stem of the Upper Mississippi River and on major tributaries immediately above their confluence with the Mississippi River.

Station Number	Miles Above Camden	Station Location
M-154	167	Bridge on STH-6 four miles north of Crosby
M-132	143	Bridge on SAR-3 in impoundment above Brainerd
M-130	138	$\frac{1}{2}$ mile below STP outfall below Brainerd. A long island creates backwater which channelizes STP discharge past sampling station
CW-1	130	On Crow Wing River at first bridge 1 mile above its mouth. Large dam is located 1 mile above station
M-116	121	Opposite ferry landing above Camp Ripley
M-108	113	Bridge at entrance to Camp Ripley
M-105	110	3 miles below station M-108
M-102	106	NPRR bridge by boat works above Little Falls
M-100	104.5	$\frac{1}{2}$ mile below St. Regis Paper Co. dam in Little Falls
M-99	104	$\frac{1}{2}$ mile below station M-100
M-85	95	Above power dam 2 miles north of Royalton
M-75	85	Bridge on SAR-2 just west of Rico
M-70	73	In impoundment above St. Regis Paper Co. dam in Sartell
M-69	72	Bridge below St. Regis Paper Co. dam in Sartell
S-0	70	On Sauk River at bridge near its mouth
M-68	70	New bridge on SAR-22 in Sauk Rapids
M-66	68	At St. Cloud water works intake
M-63	65	Opposite country club 2 miles below St. Cloud power dam
M-60	60	Below St. Cloud opposite farm near Long Lake
M-53	55	Opposite old ferry dock at Clearwater
M-38	38	1 mile above STH-25 bridge in Monticello
M-37	37	Opposite village park in Monticello
M-36	36	1 mile below STH-25 bridge in Monticello
M-27	27	At STH-101 bridge in Elk River
M-26	25.5	Opposite roadside park $1\frac{1}{2}$ miles below Elk River
C-0	20	On Crow River at STH-101 bridge in Dayton
M-14	14.5	At bridge and occasionally at a point $\frac{1}{2}$ mile below the Champlin bridge in Anoka
R-0	14	On Rum River at foot bridge in park in Anoka
M-13	13	$\frac{1}{2}$ mile below Rum River and $1\frac{1}{2}$ miles below Champlin bridge in Anoka. The Rum River, heavily polluted with Anoka sewage hugs the north shore and has not mixed with the river water at this station
CC	9	On Coon Creek at USH-10 bridge in Coon Rapids
M-8	8	In pool above Northern State Power Co. dam in Coon Rapids
M-6	5	At St. Paul water works intake north of Fridley
RC	5	On Rice Creek at SAR-1 bridge in Fridley
M-1	2.5	At Minneapolis water intake in Columbia Heights
M-0	0	At Camden bridge in North Minneapolis

APPENDIX IV (Cont'd.)

Sample stations on the Rum River

Station Number	Miles Above Mouth	Station Location
R-142	142	At bridge on STH-27 above dam impounding Lake Onamia
R-141	141	At bridge on CAR-13 below Onamia
R-136	136	At bridge near SAR-7 at USH-169
R-127	127	At bridge on USH-169, 10 miles south of Onamia
R-120	120	At bridge on CAR-6, $1\frac{1}{2}$ miles west of USH-169
R-112	112	At bridge on SAR-9, $1\frac{1}{2}$ miles above Milaca
R-110	110	At bridge on USH-169 just above Milaca
R-102	102	At bridge on SAR-4
R-95	95	At bridge on CAR-46 near SAR-1
R-80	80	At bridge on SAR-95 in Princeton
RW-0		On West Branch at bridge on USH-169 in Princeton
R-78	78	At bridge on SAR-2 just below Princeton
R-61	61	At bridge on STH-56, 10 miles east of Princeton
R-42	42	At bridge on STH-95 above Cambridge
R-40		$\frac{1}{2}$ mile below Colony for Epileptics at Cambridge
R-34		At bridge on SAR-5, west of Isanti
R-18		At bridge on SAR-6 just east of STH-56 at St. Francis
R-13		At bridge on SAR-4 just east of SAR-6, 5 miles below St. Francis
R-7		At bridge on SAR-6, 6 miles N. of Anoka
R-2		At farm just above State Hospital in Anoka
R-0		At foot bridge in park in Anoka

Sample stations on Crow River - North Fork and Buffalo Creek

Station Number	Miles Above Mouth	Station Location
CN-10	91	Bridge $3\frac{1}{2}$ miles above junction of Jewett Creek
CN-9	89	Bridge between Jewett Creek outlet and Forest City
CN-8	84	Below Forest City, bridge 2 miles above town
CN-7	75	$\frac{1}{2}$ mile below Kingston
CN-6	53	Below Cokato, bridge on SAR-2
CN-5	39	Marysville - SAR-14
CN-4	36	Montrose, bridge on SAR-5
CN-3	32	Bridge on STH-25
CN-2	28	Bridge on road crossing in twp.-27
CN-44	25	Above junction with South Fork
B-95	66	Above Glencoe, southwest of town on USH-212
B-92	63	Below Glencoe, southeast of town
B-87	59	Above Plato, bridge on USH-212
B-84	56	Below Plato, bridge on CAR-68

APPENDIX IV (Cont'd.)

Sample stations on Crow River - South Fork and Main Stem

Station Number	River Miles Above Dayton	Station Location
CS-151	75	Above Hutchinson at dam impounding Otter Lake
CS-150	74	Below Hutchinson, bridge on SAR-22
CS-78	53	Above Lester Prairie
CS-77	52	Below Lester Prairie
CS-65	42	Below Mayor
CS-59	38	Above Watertown, bridge on trunk highway -25
CS-58	36	Below Watertown $\frac{1}{2}$ mile below sewer outlet
CS-51	29	Above Delano, bridge on trunk highway -12
CS-49	27	Below Delano, bridge on twp. highway -36
CM-44	25	On North Fork of Crow River two miles above its junction with South Fork on twp. highway -25
C-41	22	Above Rockford
C-39	21	$\frac{1}{2}$ mile below Rockford
C-24	17	Above Hanover on SAR-6 1 mile southwest of Hanover
C-23	15	Below Hanover, about $1\frac{1}{2}$ miles downstream from creamery
C-21	12	1 mile above St. Michael
C-1	1	Above Dayton, $\frac{1}{2}$ mile above Dayton School
C-0	0	Below Dayton, bridge on SAR-11

APPENDIX V, TABLE 1
MISSISSIPPI RIVER SURVEY DATA
ALKALINITY DETERMINATIONS (p.p.m.)

Station	1939: May	1939: June	1939: July	1939: Aug.	1939: Dec.	1940: Feb.	1946: Mar.	1949: Jan.
Number	4-8	13-15	11-13	21-23	18-21	7-9	4-8	10-18
River flow near Libby	2,200	840	1,003	871	612	400	-	-
River flow at Aitkin	-	-	-	-	-	-	1,640	730
M-154	-	-	-	-	-	-	170	160
M-132	82	110	120	120	180	200	160	160
M-130	80	110	120	140	180	220	170	170
CW-1	200	200	200	180	220	260	200	-
M-116	-	-	-	-	-	-	-	180
M-108	110	150	140	160	180	220	180	190
M-105	-	-	-	-	-	-	-	-
M-102	100	150	150	160	180	230	180	140
M-100	100	150	150	160	180	220	190	170
M-99	-	-	-	-	-	-	-	-
M-85	-	-	-	-	-	-	-	180
River flow at Royalton	5,920	2,560	2,660	1,340	1,050	885	2,730	1,580
M-75	110	150	150	160	190	230	180	180
M-70	-	-	-	-	-	-	180	180
M-69	-	-	-	-	-	-	180	180
S-0	170	170	180	170	200	280	250	270
M-68	110	150	140	160	180	220	160	180
M-66	-	150	150	160	-	-	210	190
M-63	130	150	160	160	190	215	180	-
M-60	-	-	-	-	-	-	-	190
M-53	110	150	140	170	190	-	180	190
M-38	-	-	-	-	-	-	-	190
M-37	120	170	160	170	200	-	180	-
M-36	-	-	-	-	-	-	-	180
River flow at Elk River	9,500	3,400	3,870	2,180	1,540	1,070	3,560	1,840
M-27	-	-	-	-	-	-	-	180
M-26	130	160	160	180	180	-	190	180
C-0	210	250	200	230	290	-	-	360
M-14	120	170	170	180	190	-	180	200
R-0	150	170	150	170	190	-	170	200
River flow at Anoka	11,350	4,270	4,730	2,590	1,830	1,230	4,280	2,100
M-13	150	160	160	180	190	-	180	200
CC	-	-	-	-	-	-	-	170
M-8	130	160	140	170	190	-	180	200
M-6	-	-	-	-	-	-	170	200
RC	-	-	-	-	-	-	220	220
M-1	-	-	-	-	-	-	190	200
M-0	130	170	160	170	200	-	190	200

Note -- River flows are in cubic foot per second.

APPENDIX V, TABLE 2
MISSISSIPPI RIVER SURVEY DATA
TURBIDITY DETERMINATIONS (p.p.m.)

Station Number	1939: May : 4-8	1939: June: 13-15	1939: July : 11-13	1939: Aug.: 21-23	1939: Dec.: 18-21	1940: Feb.: 7-9	1946: Mar.: 4-8	1949: Jan.: 10-18	1951: Aug.: 15-20	1951: Au. 13-
River flow near Libby	2,200	840	1,003	871	612	400	-	-	-	
River flow at Aitkin	-	-	-	-	-	-	1,640	730	2,250	
M-154	-	-	-	-	-	-	10	5	-	
M-132	8	7	15	5	2	2	4	4	14	
M-130	15	10	14	5	1	4	8	11	20	
CW-1	4	5	4	2	1	3	4	-	4	
M-116	-	-	-	-	-	-	-	4	8	
M-108	9	7	7	2	2	2	5	3	6	
M-105	-	-	-	-	-	-	-	-	-	
M-102	6	10	9	3	3	2	6	4	8	
M-100	10	15	10	4	2	2	19	7	14	
M-99	-	-	-	-	-	-	-	-	-	
M-85	-	-	-	-	-	-	-	4	6	
River flow at Royaltan	5,920	2,560	2,660	1,340	1,050	885	2,730	1,580	3,560	12,4
M-75	7	10	5	3	2	2	8	5	14	
M-70	-	-	-	-	-	-	6	5	8	
M-69	-	-	-	-	-	-	10	4	7	
S-0	4	10	5	3	2	2	10	5	10	
M-68	10	10	8	4	2	11	15	8	5	
M-66	-	8	6	3	-	-	8	2	8	
M-63	6	7	6	2	2	2	7	-	7	
M-60	-	-	-	-	-	-	-	4	6	
M-53	7	8	5	2	2	-	8	2	5	
M-38	-	-	-	-	-	-	-	1	3	
M-37	4	8	5	1	7	-	6	-	-	
M-36	-	-	-	-	-	-	-	4	6	
River flow at Elk River	9,500	3,400	3,870	2,180	1,540	1,070	3,560	1,840	4,670	
M-27	-	-	-	-	-	-	-	2	6	
M-26	10	10	8	5	2	-	8	4	8	
C-0	35	10	80	15	10	-	-	2	22	
M-14	9	10	15	5	2	-	8	2	8	
R-0	9	8	10	5	4	-	7	3	12	
River flow at Aitkin	11,350	4,270	4,730	2,590	1,830	1,230	4,280	2,100	6,610	
M-13	10	12	7	5	6	-	-	1	-	
CC	-	-	-	-	-	-	-	4	-	
M-8	8	12	9	5	3	-	7	3	14	
M-6	-	-	-	-	-	-	6	3	13	
RC	-	-	-	-	-	-	10	2	-	
M-1	-	-	-	-	-	-	6	2	9	
M-0	8	15	15	5	3	-	8	2	17	

Note -- River flows are in cubic feet per second

APPENDIX V, TABLE 3
MISSISSIPPI RIVER SURVEY DATA
COLOR DETERMINATIONS (p.p.m.)

Station Number	1939: May :	1939: June:	1939: July:	1939: Aug.:	1939: Dec.:	1940: Feb.:	1946: Mar.:	1949: Jan.:	1951: Aug.:
	4-8 :	13-15:	11-13:	21-23:	18-21:	7-9 :	4-8 :	10-18:	15-20:
River flow near Libby	2,200	840	1,003	871	612	400	-	-	-
River flow at Aitkin	-	-	-	-	-	-	1,640	730	2,250
M-154	-	-	-	-	-	-	27	30	-
M-132	100	100	20	33	28	32	25	20	30
M-130	110	110	120	35	32	38	26	20	25
CW-1	35	30	45	25	18	16	16	-	25
M-116	-	-	-	-	-	-	-	18	25
M-108	100	75	85	33	26	23	20	15	25
M-105	-	-	-	-	-	-	-	-	-
M-102	95	75	80	32	27	25	25	16	30
M-100	100	80	90	33	23	24	24	15	40
M-99	-	-	-	-	-	-	-	-	-
M-85	-	-	-	-	-	-	-	17	35
River flow at Royalton	5,920	2,560	2,660	1,240	1,050	885	2,730	1,580	3,560
M-75	90	80	80	38	22	23	25	16	35
M-70	-	-	-	-	-	-	25	17	40
M-69	-	-	-	-	-	-	25	18	35
S-0	23	40	40	30	19	24	28	16	35
M-68	90	65	80	40	22	26	30	15	35
M-66	-	55	75	38	-	-	24	15	35
M-63	90	65	80	40	22	20	25	-	35
M-60	-	-	-	-	-	-	-	16	35
M-53	90	50	80	38	22	-	26	16	35
M-38	-	-	-	-	-	-	-	15	35
M-37	80	50	80	38	20	-	25	-	-
M-36	-	-	-	-	-	-	-	17	35
River flow at Elk River	9,500	3,400	3,870	2,180	1,540	1,070	3,560	1,840	4,670
M-27	-	-	-	-	-	-	-	14	35
M-26	75	50	70	35	21	-	25	15	40
C-0	55	45	80	33	23	-	-	16	100
M-14	80	45	70	35	25	-	26	13	35
R-0	80	70	90	37	22	-	25	16	60
River flow at Anoka	11,350	4,270	4,730	2,590	1,830	1,230	4,280	2,100	6,610
M-13	75	70	90	38	20	-	25	15	-
CC	-	-	-	-	-	-	-	21	-
M-8	80	50	80	36	20	-	25	16	40
M-6	-	-	-	-	-	-	25	17	40
RC	-	-	-	-	-	-	50	20	-
M-1	-	-	-	-	-	-	25	16	50
M-0	80	55	70	35	19	-	25	16	45

Note -- River flows are in cubic feet per second.

APPENDIX V, TABLE 4
MISSISSIPPI RIVER SURVEY DATA
pH DETERMINATIONS

Station Number	1939: May : 4-8	1939 : June : 13-15	1939 : July : 11-13	1939 : Aug. : 21-23	1939 : Dec. : 18-21	1940 : Feb. : 7-9	1946 : Mar. : 4-8	1949 : Jan. : 10-18	1952 : Apr.29: May 6	1952 : Aug. : 13-14
River flow near Libby	2,200	840	1,003	871	612	400	-	-	-	
River flow at Aitkin	-	-	-	-	-	-	1,640	730	8,350	
M-154	-	-	-	-	-	-	7.4	7.3	-	
M-132	7.4	7.7	8.1	8.0	7.9	7.0	7.4	7.4	7.6	
M-130	7.5	7.7	7.5	7.7	7.9	7.0	7.4	7.4	7.6	
CW-1	8.1	8.1	8.4	8.3	8.1	7.3	7.4	-	8.0	
M-116	-	-	-	-	-	-	-	7.6	7.7	
M-108	7.8	8.0	8.1	8.4	8.0	7.2	7.5	7.6	7.9	7.6
M-105	-	-	-	-	-	-	-	-	-	7.4
M-102	7.7	8.0	8.3	8.2	8.0	7.2	7.5	7.6	7.9	7.5
M-100	7.6	7.8	8.2	7.8	8.0	7.3	7.4	7.2	7.8	-
M-99	-	-	-	-	-	-	-	-	-	7.6
M-85	-	-	-	-	-	-	-	7.2	7.8	7.6
River flow at Royalton	5,920	2,560	2,660	1,320	1,050	885	2,730	1,580	15,400	12,400
M-75	7.6	7.7	8.1	7.9	8.1	7.3	7.4	7.3	8.0	7.4
M-70	-	-	-	-	-	-	7.4	7.4	8.0	-
M-69	-	-	-	-	-	-	7.4	7.2	8.4	-
S-0	7.8	8.4	8.3	8.0	8.0	7.4	7.6	7.4	8.2	8.3
M-69	7.5	7.9	8.2	8.1	8.0	7.7	7.4	7.4	8.1	7.5
M-66	-	8.2	8.4	8.0	-	-	7.4	7.4	7.7	
M-63	7.3	7.9	8.2	8.4	8.1	7.7	7.6	-	8.1	
M-60	-	-	-	-	-	-	-	7.5	8.1	
M-53	7.7	7.9	8.2	8.4	8.2	-	7.5	7.6	8.1	
M-38	-	-	-	-	-	-	-	7.4	8.2	
M-37	7.6	8.3	8.3	8.4	8.2	-	7.4	-	-	
M-36	-	-	-	-	-	-	-	7.5	8.1	
River flow at Elk River	9,500	3,400	3,870	2,180	1,540	1,070	3,560	1,840	21,200	
M-27	-	-	-	-	-	-	-	7.4	8.2	
M-26	7.2	8.4	8.4	8.1	8.1	-	7.4	7.5	8.3	
C-0	7.7	8.3	8.4	8.2	8.3	-	-	7.6	8.1	
M-14	8.0	8.1	8.4	8.3	8.4	-	7.5	7.4	8.3	
R-0	7.8	7.9	8.3	8.0	8.0	-	7.4	7.8	8.2	
River flow at Anoka	11,350	4,270	4,730	2,590	1,830	1,230	4,280	2,100	31,000	
M-13	7.7	7.9	8.3	8.2	8.2	-	7.5	7.4	8.1	
CC	-	-	-	-	-	-	-	7.5	-	
M-8	7.8	8.1	8.4	8.3	8.2	-	7.5	7.5	-	
M-6	-	-	-	-	-	-	8.0	7.6	7.9	
RC	-	-	-	-	-	-	7.6	7.4	-	
M-1	-	-	-	-	-	-	8.0	7.5	8.2	
M-0	7.7	7.8	8.5	8.3	8.2	-	7.5	7.6	8.2	

Note -- River flows are in cubic feet per second.

APPENDIX V, TABLE 5
MISSISSIPPI RIVER SURVEY DATA
DISSOLVED OXYGEN DETERMINATION (p.p.m.)

Station Number	1939: May : 4-8 :	1939: June : 13-15 :	1939: July : 11-13 :	1939: Aug. : 21-23 :	1939: Dec. : 18-21 :	1940: Feb. : 7-9 :	1946: Mar. : 4-8 :	1949: Jan. : 10-18 :	1951: Aug. : 15-20 :	1952 : Apr. 29 : May 6 :	1952 : Aug. : 13-14 :
River flow near Libby	2,200	840	1,003	871	612	400	-	-	-	-	
River flow at Aitkin	-	-	-	-	-	-	1,640	730	2,250	8,350	
M-154	-	-	-	-	-	-	6.3	6.3	-	-	
M-132	8.0	6.8	4.0	8.6	8.7	4.4	7.2	9.5	6.6	7.0	
M-130	8.2	6.0	3.8	7.2	7.7	6.2	7.1	8.3	6.2	7.1	
CW-1	9.7	6.8	7.1	10.6	9.2	6.5	6.2	-	10.8	8.7	
M-116	-	-	-	-	-	-	-	6.9	7.4	7.8	
M-108	8.4	8.4	6.4	10.8	8.6	5.8	5.9	6.5	8.4	7.4	5.5
M-105	-	-	-	-	-	-	-	-	-	-	5.7
M-102	7.3	7.5	5.7	8.0	7.9	4.0	6.0	6.2	7.3	7.6	5.8
M-100	8.1	8.1	5.2	7.2	7.7	6.0	6.2	6.7	7.1	7.6	-
M-99	-	-	-	-	-	-	-	-	-	-	6.0
M-85	-	-	-	-	-	-	-	6.1	6.9	7.5	6.2
River flow at Royalton	5,920	2,560	2,660	1,340	1,050	885	2,730	1,580	3,560	15,400	12,400
M-75	8.5	6.8	4.2	6.2	7.7	7.6	5.4	6.4	7.9	8.1	6.9
M-70	-	-	-	-	-	-	5.3	7.1	7.3	8.3	-
M-69	-	-	-	-	-	-	5.7	8.9	6.8	8.4	-
S-0	9.1	9.4	7.0	7.3	8.8	11.2	6.3	9.1	8.4	8.0	8.5
M-68	8.3	8.4	6.0	7.2	8.2	8.8	6.3	8.8	7.5	8.1	7.2
M-66	-	-	-	5.8	-	-	6.4	8.1	7.5	8.0	
M-63	8.5	10.0	6.4	8.7	9.1	9.6	6.9	-	8.6	8.4	
M-60	-	-	-	-	-	-	-	8.3	8.9	8.2	
M-53	8.5	7.8	5.2	7.4	8.5	-	7.1	8.0	8.2	8.4	
M-38	-	-	-	-	-	-	-	-	8.8	7.9	
M-37	8.7	10.4	9.3	8.8	8.8	-	6.1	8.5	-	-	
M-36	-	-	-	-	-	-	-	8.9	8.8	7.6	
River flow at Elk River	9,500	3,400	3,870	2,180	1,540	1,070	3,560	1,840	4,670	21,200	
M-27	-	-	-	-	-	-	-	8.2	8.7	7.6	
M-26	8.7	10.5	7.3	8.7	9.3	-	8.0	9.1	7.6	7.5	
C-0	8.5	11.8	7.0	7.2	7.9	-	-	10.9	7.1	2.0	
M-14	7.5	7.3	6.0	7.7	9.3	-	6.7	7.9	7.8	7.6	
R-0	-	-	-	-	-	-	10.7	11.6	8.3	7.0	
River flow at Anoka	11,350	4,270	4,730	2,590	1,830	1,230	4,280	2,100	6,610	31,000	
M-13	8.0	7.6	7.3	7.6	8.9	-	7.2	7.9	-	7.5	
CC	-	-	-	-	-	-	-	10.0	-	7.7	
M-8	7.9	7.8	5.9	7.9	8.5	-	8.0	8.8	8.2	7.6	
M-6	-	-	-	-	-	-	8.5	9.4	8.1	7.8	
RC	-	-	-	-	-	-	8.6	10.8	-	7.2	
M-1	-	-	-	-	-	-	8.1	9.8	8.1	7.9	
M-0	8.5	7.0	6.9	8.3	8.5	-	7.6	9.6	8.2	8.1	

Note -- River flows are in cubic feet per second.

APPENDIX V, TABLE 6
MISSISSIPPI RIVER SURVEY DATA
BIOCHEMICAL OXYGEN DEMAND (BOD) DETERMINATIONS p.p.m.

Station Number	1949 Jan. 10-18	1951 Aug. 15-20	1952 Apr. 29 May 6	1952 Aug. 13	1952 Aug. 14
River flow at Aitkin	730	2,250	8,350		
M-154	3.0	-	-		
M-132	2.4	1.5	1.5		
M-130	5.3	12.0	1.2		
CW-1	-	1.5	.8		
M-116	1.0	.9	1.3		
M-108	1.5	1.1	2.4	1.4	.2
M-105	-	-	-	1.0	.7
M-102	1.1	1.1	1.8	1.2	.4
M-100	-	4.7	2.1	-	-
M-99	-	-	-	.9	3.5
M-85	4.4	.9	1.3	1.4	.6
River flow at Royalton	1,580	3,560	15,400	12,500	12,300
M-75	.7	1.7	1.5	1.1	1.1
M-70	8.7	1.1	1.3	-	-
M-69	1.4	1.1	1.7	-	-
S-0	.5	1.7	2.5	1.8	1.5
M-68	1.7	.8	1.6	1.6	.5
M-66	1.3	1.0	.3		
M-63	-	1.1	.8		
M-60	2.7	.9	.7		
M-53	2.3	1.0	.8		
M-38	1.9	.9	2.1		
M-37	-	-	-		
M-36	4.8	1.6	1.3		
River flow at Elk River	1,840	4,670	21,200		
M-27	1.0	1.5	1.2		
M-26	1.9	1.0	2.6		
C-0	1.2	2.6	6.4		
M-14	1.7	1.0	1.8		
R-0	2.0	2.2	2.4		
River flow at Anoka	2,100	6,610	31,000		
M-13	2.1	-	2.2		
CC	1.0	-	-		
M-8	1.6	1.9	2.2		
M-6	1.3	1.4	1.3		
RC	1.0	-	-		
M-1	2.0	1.4	2.1		
M-0	1.1	1.8	1.5		

Note -- River flows are in cubic feet per second.

APPENDIX V, TABLE 7
MISSISSIPPI RIVER SURVEY DATA

MOST PROBABLE NUMBER OF COLIFORM BACTERIA PER 100 ml. (MPN)													
Station Number	1939 May 4-8	1939 June 13-15	1939 July 11-13	1939 Aug. 21-23	1939 Dec. 18-21	1940 Feb. 7-9	1946 Mar. 4-8	1949 Jan. 10-18	1951 Aug. 15-20	1951 Sept. 19-20	1952 Apr. 29 May 6	1952 Aug. 13-14	
River Flow													
Near Libby River Flow at Atkin	(2,200)	(840)	(1,003)	(871)	(612)	(400)	--	--	--	--	--	--	
M-154	--	--	--	--	--	--	(1,640)	(730)	(2,250)	--	(8,350)	--	
M-132	49	23	46*	23	13	23	540	1,600	--	--	--	--	
Brainerd M-130	22	5					79	350	2,200	--	200	--	
	23	13									200	--	
	1,600	1,100	16,000	17,000	9,200	1,700	700	920,000	17,000,000	--	92,000	--	
	5,400	35,000	35,000	35,000	16,000		1,100	1,600			200	--	
CW-1	7	130	920	540	23	3	33	--	740	--	200	--	
M-116	--	--	--	--	--	--	--	3,500	7,800	--	200	--	
									6,800	--	200	--	
M-108	920	490	1,100	230	2,400	5,400	790	9,200	4,500	--	450	--	
	1,200	700	640	130		2,800			16,000	--	400	4,900	
	700	230	330	130						--	450	2,300	
Camp Ripley M-105	--	--	--	--	--	--	--	--	--	--	--	7,900	
													780
													2,700

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APPENDIX V, TABLE 7 (Cont'd.)

Station Number	1939 May 4-8	1939 June 13-15	1939 July 11-13	1939 Aug. 21-23	1939 Dec. 18-21	1940 Feb. 7-9	1946 Mar. 4-8	1949 Jan. 10-18	1951 Aug. 15-20	1951 Sept. 19-20	1952 Apr. 29 May 6	1952 Aug. 13-14
M-102	1,700 1,600 1,100	490 230 330	1,700 1,100 3,500	230 790 2,200	790 2,400 3,100	1,700 3,500 3,500	490	3,500	3,300	---	680 450 400	2,300 2,300 2,930 2,300 780 1,100
Little Falls M-100	540 2,200 2,200	260 4,600 5,400 2,400 2,200	16,000 11,000 35,000	7,900 3,300 4,900	1,300 1,700 2,200	3,500 3,500 3,500	1,700 330 5,400	24,000	240,000 ****	---	---	---
M-99	---	---	---	---	---	---	---	---	---	---	---	3,300 4,600 2,000 3,300 3,300 13,000 2,300 2,200 1,700 1,700 1,100 2,300
M-85	---	---	---	---	---	---	---	3,500	450	---	780 450 780	2,300 2,200 1,700 1,700 1,100 2,300
Royalton River Flow At Royalton M-75	(5,921 541 921 541	560) 330 310 330	(2,660) 330 230 140	(1,340) 230 130 230	(1,050) 170 490 330	(385) 4,300 9,200 3,500	(2,730) 790	(1,580) 5,400	(3,560) 490	---	(15,400) 680 200 200	(12,400) 680 4,900 780 2,300 2,200 13,000
Rice M-70	---	---	---	---	---	---	790	1,100	450	---	450	---

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APPENDIX V, TABLE 7 (Cont'd.)

Station Number	1939 May 4-8	1939 June 13-15	1939 July 11-13	1939 Aug. 21-23	1939 Dec. 18-21	1940 Feb. 7-9	1946 Mar. 4-8	1949 Jan. 10-18	1951 Aug. 15-20	1951 Sept. 19-20	1952 Apr. 29 May 6	1952 Aug. 13-14
Sartell M-69	--	--	--	--	--	--	460 330	790	220	--	200 1,300 200	--
S-O	540	270	490	460*	2,400	790	2,200	1,000	3,300	--	3,300	4,900 13,000
M-68	170 1,600 540	790 490 1,100	170 330 330	230 78 45	350 350 540	480 7,000 5,500	1,100	790	1,300	--	200 200 450	2,200 1,300 1,300 3,300
Sauk Rapids M-66	230	220	490	1,100	1,600	5,400	490	3,500	1,100	--	1,700 780 3,300	--
Saint Cloud M-63	16,000	16,000 3,500	7,000 9,200	4,900 3,300	24,000 16,000	16,000 7,000	1,700	--	11,000	--	4,900	--
M-60	--	--	--	--	--	--	--	16,000	7,900	--	6,400	--
M-53	1,700 1,700 1,600	1,300 1,700 5,400	1,100*	1,300*	7,000*	--	790	5,400	54,000	--	2,200	--
M-38	--	--	--	--	--	--	--	790	17,000	--	1,100	--
Monticello M-37	3,500	3,500 490	16,000 1,100	3,500 130	2,400 1,700	--	16,000	--	--	--	--	--
M-36	--	--	--	--	--	--	--	92,000	160,000	--	3,300	--

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APPENDIX V, TABLE 7 (Cont'd.)

Station Number	1939 May 4-8	1939 June 13-15	1939 July 11-13	1939 Aug. 21-23	1939 Dec. 16-21	1940 Feb. 7-9	1946 Mar. 4-6	1949 Jan. 10-16	1951 Aug. 17-20	1951 Sept. 19-20	1952 Apr. 29 May 6	1952 Aug. 13-14
River Flow Near Elk River M-27	(9,500) --	(3,400) --	(3,870) --	(2,180) --	(1,540) --	(1,070) --	(3,560) --	(1,840) 330 790 1,100	(4,670) 4,900 2,300 2,300	--	(21,200) 2,200 3,300 2,300	--
Elk River M-26	540	700 3,500 2,400	790 1,700 3,500	2,400 1,700 1,700	2,400 3,500	--	1,700	5,400 1,300 3,100	7,900	--	4,900	--
C-0	1,100 840	2,400 3,500	1,700	1,300*	23	--	--	--	2,300	--	1,700	--
M-14	920 460 350	490 3,500 3,500	490 490 330	490 460 1,300	460 700 230	--	3,500	1,100 640 2,400	7,900 2,300 4,600	7,900 13,000 2,300	2,300	--
R-0	3,500 3,500	490 490	2,400*	2,400*	16,000*	--	3,500	3,500 2,300 4,900	780	13,000	2,300	--
Anoka River Flow At Anoka M-13	(11,350) 1,600 17,000	(4,270) 4,600 1,700	(4,730) 2,400 1,300	(2,590) 430 17,000	(1,830) 170 9,200	(1,230) --	(4,280) 24,000	(2,100) 13,000 2,200 680	(6,610) --	(14,800) 3,300 14,000	(31,000) 17,000	-- --
CC	--	--	--	--	--	23	--	170	3,300	1,300	4,900	--
N-8	920 3,500	490 460	230 330	2,400 2,400	950 1,100	--	2,400	1,300	7,900	14,000 92,000	3,300 17,000 4,900	--

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APPENDIX V, TABLE 7 (Cont'd.)

Station Number	1939 May 4-8	1939 June 13-15	1939 July 11-13	1939 Aug. 21-23	1939 Dec. 18-21	1940 Feb. 7-9	1946 Mar. 4-8	1949 Jan. 10-13	1951 Aug. 15-20	1951 Sept. 19-20	1952 Apr. 29 May 6	1952 Aug. 13-14
Coon Rapids												
M-6	--	--	--	--	--	--	5,400	1,300	6,400	7,900	1,700	--
RC	--	--	--	--	--	--	1,700	330	1,300	1,300	200	--
M-1	--	--	--	--	--	--	9,200	1,300	3,300	13,000	1,700	--
M-0	920 2,400 1,700	1,700 1,700 1,700	130 *	230 *	490 490 1,700	--	2,200	1,100	3,300	13,000 1,100	3,300 2,100 1,300	--

* Composite of three samples.

** Sample collected below Brainerd on the east side of the river where sewage plant effluent flows along the east bank and has not mixed with the river flow. Results not included in summary tables.

*** Brainerd sewage treatment plant being by-passed.

**** Sample collected at point where paper mill effluent discharges into river. As effluent has not thoroughly mixed with river water this result is not included in summary tables.

APPENDIX V, TABLE 8
VARIATIONS IN RUM RIVER SURVEY DATA (1939 - 1952)

Sample Station	Turbidity P.p.m.			Color p.p.m.			Alkalinity P.p.m.			pH		D.O. p.p.m.			B.O.D. P.p.m.		
	Ave	max	min	Ave	max	min	Ave	max	min	max	min	Ave	max	min	Ave	max	min
R-142	6	20	3	60	100	40	93	280	79	8.8	7.0	6.0	10.0	0.0	9.2	24.0	1.8
Onamia																	
R-141	10	32	4	70	100	40	147	290	79	8.8	7.1	6.4	10.0	0.1	9.2	24.0	1.6
R-136	-	-	-	-	-	-	-	-	-	8.2*	-	-	10.5*	-	-	-	1.9*
R-127	-	-	3*	-	-	25*	-	280*	-	8.2	7.2	6.3	11.3	1.3	4.0	6.3	1.7
R-120	-	-	-	-	-	-	-	-	-	8.3*	-	-	11.0*	-	-	-	1.8*
R-112	4	5	3	75	140	20	154	300	85	8.3	7.5	7.2	11.1	1.0	2.3	3.8	1.4
Milaca																	
R-110	8	17	1	73	140	20	155	260	110	8.4	7.1	6.5	11.2	0.2	2.7	4.6	1.6
R-102	-	-	-	-	-	-	-	-	-	8.4*	-	-	10.8*	-	-	-	1.4*
R-95	-	-	3*	-	-	22*	-	260*	-	8.4	7.2	-	10.7	-	1.6	2.0	0.8
R-80	8	25	1	62	135	13	175	270	32	8.3	7.3	5.8	9.3	2.1	1.7	2.1	1.5
Princeton																	
RW-0	6	15	2	50	80	13	112	170	54	8.1	7.3	7.2	9.4	5.0	2.0	3.0	1.3
R-78	8	20	2	40	95	12	161	240	78	8.1	7.2	6.1	10.0	4.2	3.4	4.8	2.0
R-61	-	-	7*	-	-	22*	-	210*	-	8.0	7.5	5.1	9.2	1.0	1.9	2.4	1.3
R-42	6	15	2	57	130	20	155	230	94	8.4	6.5	5.5	9.2	1.5	1.9	2.9	1.3
Cambridge																	
R-40	7	10	4	53	120	19	143	220	91	8.4	7.0	5.4	9.3	1.8	4.1	5.7	2.8
R-34	6	10	3	53	120	22	151	220	90	8.8	7.0	5.7	11.0	1.7	5.0	10.0	1.5
R-18	6	8	4	25	28	21	-	210*	-	8.1	7.2	4.5	10.0	1.1	2.3	3.1	1.7
St. Francis																	
R-13	5	6	4	21	24	17	190	210	170	8.2	7.5	5.7	10.4	3.3	2.7	4.0	1.6
R-7	5	10	2	46	110	16	143	200	85	8.4	7.4	6.6	10.0	4.3	3.0	4.6	1.7
R-2	6	10	2	19	22	15	-	200*	-	8.2	7.2	6.8	9.8	4.0	2.8	4.4	2.0
R-0	5	12	2	50	110	16	151	200	85	8.6	7.3	8.4	10.3	6.3	2.5	3.3	1.7

* Only one sample.

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APPENDIX V, TABLE 9
RUM RIVER SURVEY DATA

MOST PROBABLE NUMBER OF COLIFORM BACTERIA PER 100 ml. (MPN)												
Station	1939	1939	1939	1939	1939	1940	1948	1949	1951	1952	Arithmetic Average	
Number	May 31	June 19	June 28	July 18	Oct. 2	Feb. 2	July 13-15	Jan. 20-25	Mar. 26-27	May 12-14		
R-142	20	14	-	55	1,300	-	46	23	-	200	200	240
Onamia												
R-141	200	200	-	1,300	1,500	-	78	33	-	200	200	500
R-136	-	-	-	-	-	-	-	-	-	200	200	-
R-127	-	-	-	-	-	-	-	5	-	< 200	< 200	-
R-120	-	-	-	-	-	-	-	-	-	1,300	1,300	-
R-112	1,400	190	-	1,050	130	13	170	5	-	< 200	< 200	400
Milaca												
R-110	8,000	80,000	-	10,400	5,500	2,900	24,000	18,000	-	9,600	9,600	18,000
R-102	-	-	-	-	-	-	-	-	-	450	450	-
R-95	-	-	-	-	-	-	-	2	-	780	780	-
R-80	540	900	-	260	2,500	12	2,400	5	-	2,300	2,300	1,000
RW-0	210	550	-	520	650	12	5,400	170	-	< 200	< 200	950
Princeton												
R-78	6,700	6,400	-	12,000	60,000	63,000	17,000	119,000	-	7,400	7,400	43,000
R-61	-	-	-	-	-	-	-	5,400	-	3,300	3,300	4,400
R-42	1,700	-	800	210	1,200	39	170	330	9,200	400	400	1,300
Cambridge												
R-40	11,000	-	7,000	7,200	13,000	1,900	160,000	103,000	92,000	11,000	11,000	42,000
R-34	13,000	-	5,200	11,500	24,000	6,700	24,000	16,000	14,000	7,900	7,900	13,000
R-18	-	-	-	-	-	-	-	9,200	4,900	4,900	4,900	6,000
St. Francis												
R-13	-	-	-	-	-	-	-	700	5,400	1,300	1,300	2,500
R-7	1,500	-	1,500	350	130	1,300	790	330	3,500	3,300	3,300	1,200
R-2	-	-	-	-	-	-	-	240	460	1,300	1,300	700
R-0	1,100	-	4,700	2,400	650	1,700	790	3,500	920	3,300	3,300	2,300

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APPENDIX V, TABLE 10
VARIATIONS IN CROW RIVER SURVEY DATA (1939 - 1948)

Station Number	: Turbidity p.p.m. :			: Color p.p.m. :			: Alkalinity p.p.m. :			: pH :			: D.O. p.p.m. :			: B.O.D. ** :		
	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Max	Min	Ave	Max	Min	Ave	Max	Min	p.p.m.
CS-151	65	80	55	67	60	50	130	230	120	8.7	7.5	7.5	10.3	4.6				7.3
Hutchinson																		
CS-150	59	130	6	48	60	25	220	360	150	8.3	7.2	7.2	9.5	12.2	4.1			11.0
CS-78	141	230	65	81	110	60	210	240	190	9.0	7.2	7.2	11.3	13.7	5.8			18.0
Lester Prairie																		
CS-77	121	200	55	77	110	52	210	250	190	8.9	6.9	6.9	11.0	13.5	7.7			17.0
CS-65	93	150	60	73	110	52	210	250	180	8.8	7.3	7.3	7.4	14.0	3.1			11.0
CS-59	72	140	55	78	110	52	390	1160	170	8.7	7.0	7.0	8.8	18.5	0.0			13.0
Watertown																		
CS-58	77	150	25	69	100	45	270	510	180	8.7	6.4	6.4	4.4	7.2	0.0			12.0
CS-51	65	140	30	79	110	55	280	530	170	8.8	6.7	6.7	4.9	11.2	0.0			13.0
Delano																		
CS-49	57	130	10	67	110	21	270	550	160	8.6	6.8	6.8	6.2	9.3	0.0			11.7
C-41	65	130	8	55	90	25	270	440	210	8.2	7.0	7.0	5.2	7.5	0.4			8.0
Rockford																		
C-39	68	130	26	51	85	17	270	450	200	8.8	7.5	7.5	5.7	8.8	1.9			5.3
C-24	71	140	4	59	80	29	260	450	190	8.2	7.2	7.2	5.2	9.2	0.9			5.7
C-23	50	66	2	50	90	16	270	480	180	8.0	7.6	7.6	6.0	7.2	5.1			5.6
C-1	42	70	4	47	70	18	250	420	170	8.4	7.8	7.8	7.6	10.6	5.9			9.5
Dayton																		
C-0	33	56	4	45	75	17	240	420	130	8.2	7.7	7.7	7.6	11.1	5.2			11.0
CN-44	50	100	2	36	45	14	280	410	210	8.2	6.9	6.9	4.7	6.2	1.7			3.7
CN-4	-	-	3*	-	-	15*	-	400*	-	-	7.3*	7.3*	-	-	2.8*			
CN-3	-	-	3*	-	-	15*	-	400*	-	-	7.3*	7.3*	-	-	2.0*			
CN-2	-	-	3*	-	-	16*	-	400*	-	-	7.4*	7.4*	-	-	2.2*			
B-95	62	80	45	68	80	60	220	260	185	7.9	7.5	7.5						
Glencoe																		
B-92	70	80	55	75	85	60	210	250	170	7.9	7.3	7.3						
B-87	63	70	55	75	100	60	210	230	180	7.9	7.3	7.3						
B-84	66	80	40	77	90	70	210	230	200	7.9	7.2	7.2						

* Only one sample.

** B.O.D. samples were collected only on the 1948 survey. Industrial wastes believed to be responsible for these high values are no longer being discharged to the river.

APPENDIX V, TABLE 11
CROW RIVER SURVEY DATA
MOST PROBABLE NUMBER OF COLIFORM BACTERIA PER 100 ml. (MPN)

Station	1939 : June : 7	1939 : June : 26	1939 : July : 24	1939 : Sept. : 6-8	1939 : Oct. : 2	1940 : Jan. : 25-26	1948 : July : 6-12
Number	7	26	24	6-8	2	25-26	6-12
CS-151	1,300	490	490	-	-	-	230
Hutchinson							
CS-150	49,000	35,000	35,000	240,000			350,000
CS-78	9,200	780	2,300	3,300	-	-	1,700
Lester Prairie							
CS-77	5,400	7,900	4,900	11,000	-	-	3,500
CS-65	13,000	3,300	2,300	7,900	-	-	1,300
CS-59	2,400	5,400	3,300	3,300	-	45	790
Watertown							
CS-58	13,000	45,000	35,000	1,600,000	-	670,000	54,000
CS-51	10,000	8,200	1,800	2,800	-	160,000	790
Delano							
CS-49	15,000	7,900	13,000	6,700	-	54,000	17,000
C-41	7,000	7,000	1,300	35,000	-	1,700	790
Rockford							
C-39	21,000	10,000	2,200	18,000	-	330	5,400
C-24	1,600	3,400	1,300	24,000	-	1,700	130
C-23	1,200	3,600	3,700	6,000	-	350	1,700
C-21	-	-	-	-	-	-	310
C-1	4,800	3,400	1,700	2,500	-	20	920
Dayton							
C-0	5,000	3,300	3,100	7,500	-	22	920
CN-10	-	-	-	-	920	-	-
CN-9	-	-	-	-	330	-	-
CN-8	-	-	-	-	490	-	-
Kingston							
CN-7	-	-	-	-	9,200	-	-
Cokato							
CN-6	-	-	-	-	3,500	-	-
CN-5	-	-	-	-	1,700	-	-
CN-4	-	-	-	-	790	20	-
CN-3	-	-	-	-	3,100	250	-
CN-2	-	-	-	-	2,200	23	-
CN-44	5,400	1,100	490	4,800	790	22	330
B-95	1,600	4,900	24,000	-	-	-	-
Glencoe							
B-92	7,000	92,000	92,000	-	-	-	-
B-87	24,000	22,000	7,000	-	-	-	-
B-84	7,900	5,600	2,300	-	-	-	-

APPENDIX V, TABLE 12
SAUK RIVER SURVEY DATA AUGUST 2-4, 1949

Station Location	Miles Above Mouth	Coliform		Turbid- ity P.P.m.	Color P.P.m.	Alka- linity P.P.m.	pH	D.O. P.P.m.	B.O.D. P.P.m.
		Bacteria per 100 ml. (MPN)							
Osakis	105	49		11	18	160	8.7	9.5	3.1
Osakis	102	79,000		7	34	200	7.6	9.0	1.5
Above Little Sauk	92	170		23	32	170	9.0	10.8	8.2
Below Little Sauk	88	1,600		9	23	190	8.4	11.3	1.9
Above Sauk Center	81	49		30	27	150	9.1	9.8	12.0
Below Sauk Center	77	3,500		34	32	150	8.5	5.0	9.2
Above Melrose	68	13,000		26	50	160	7.6	5.0	6.4
Below Melrose, 1 mi.	64	3,500		6	33	170	7.6	4.8	6.6
Above New Munich	59	490		7	35	190	7.6	3.5	2.4
Below New Munich	56	330		5	33	200	7.8	5.9	2.1
Above St. Martin	47	790		15	38	210	8.1	7.5	2.4
Below St. Martin	35	1,700		12	35	210	8.3	7.6	1.4
Above Richmond	28	1,700		34	35	200	8.3	6.1	1.5
Below Richmond	27	160,000		26	30	190	8.3	5.6	1.4
Below Richmond	26	330		7	25	160	8.3	4.4	3.9
Above Cold Spring	20	93		6	24	130	9.0	9.6	2.5
Below Cold Spring, 1 mi.	17	35,000		8	28	140	9.0	11.6	2.7
Below Rockville	12	54,000		6	28	160	8.6	8.8	1.8
Above Waite Park	5	490		4	25	160	8.7	13.7	1.3
Below Waite Park	3	5,400		6	25	170	8.8	12.6	1.4
St. Cloud	0	790		6	25	150	8.5	9.5	1.5

APPENDIX V, TABLE 13
MINNEAPOLIS RAW WATER BACTERIOLOGICAL DATA*
MISSISSIPPI RIVER STATION M-1
1941, 1942, and 1952

Date	MPN/100 ml	Date	MPN/100 ml	Date	MPN/100
7-28-41	1,100	11-21-41	3,500	6-16-52	780
8-1-41	260	11-27-41	1,700	6-23-52	1,700
8-3-41	270	12-2-41	3,500	6-27-52	7,000
8-5-41	790	12-4-41	2,200	7-9-52	4,900
8-7-41	790	12-9-41	2,400	7-15-52 (6:00 PM)	7,000
8-9-41	1,100	12-13-41	1,700	7-15-52 (8:00 PM)	9,000
8-11-41	700	1-6-42	1,300	7-15-52 (10:00 PM)	13,000
8-13-41	790	1-11-42	790	7-15-52 (12:00 M)	4,900
8-15-41	330	1-17-42	2,400	7-16-52 (2:00 AM)	2,300
8-17-41	1,400	1-28-42	1,700	7-16-52 (4:00 AM)	7,900
8-19-41	1,700	2-3-42	2,800	7-16-52 (6:00 AM)	4,900
8-21-41	2,400	2-6-42	5,400	7-16-52 (8:00 AM)	7,900
8-23-41	1,700	2-7-42	1,100	7-16-52 (10:00 AM)	4,900
8-25-41	1,100	2-13-42	9,200	7-16-52 (12:00 N)	4,900
8-27-41	790	2-17-42	2,200	7-16-52 (2:00 PM)	3,300
8-29-41	1,700	2-21-42	790	7-16-52 (4:00 PM)	7,000
8-31-41	2,800	2-21-42	2,200	7-28-52	7,000
9-2-41	2,200	3-11-42	3,500	8-4-52	11,000
9-4-41	2,100	3-20-42	2,400	8-11-52	7,000
9-6-41	1,700	3-31-42	790	8-18-52	7,900
9-13-41	2,200	1-7-52	7,000	8-25-52	22,000
9-15-41	5,400	1-11-52	4,900	9-1-52	17,000
9-17-41	2,400	1-21-52 (2:00 AM)	3,300	9-15-52	11,000
9-20-41	3,500	1-21-52 (4:00 AM)	1,700	9-22-52	13,000
9-27-41	5,400	1-21-52 (6:00 AM)	4,900	9-29-52	4,600
10-2-41	2,400	1-21-52 (8:00 AM)	4,900	10-6-52	2,300
10-4-41	9,200	1-21-52 (10:00 AM)	1,300	10-28-52	2,300
10-6-41	2,200	1-21-52 (12:00 N)	1,100	11-3-52	5,400
10-20-41	1,300	1-21-52 (2:00 PM)	450	11-10-52	3,500
10-25-41	1,700	1-28-52	4,900	11-20-52	1,300
10-27-41	1,700	2-4-52	3,500	11-21-52	5,400
10-30-41	3,500	4-21-52	950	12-1-52	1,700
11-3-41	1,700	4-28-52	640	12-8-52	9,200
11-5-41	2,400	5-5-52	790	12-15-52	2,400
11-8-41	3,500	5-12-52	2,200	12-22-52	3,500
11-12-41	5,400	5-19-52	3,500	12-29-52	1,700
11-17-41	3,500	5-26-52	1,700		
11-20-41	3,500	6-2-52	9,200		
		6-9-52	2,300		

* Data from Minneapolis Water Department Laboratories